

Top-Feed Vacuum Filtration of
Waste-Activated Sludge

Rexnord, Inc.
Milwaukee, WI

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Cincinnati, OH

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TOP-FEED VACUUM FILTRATION
OF WASTE-ACTIVATED SLUDGE

by

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This report presents the results of a study that looked at the technical and economical aspects of two different modes of vacuum filter operation. The results should be valuable in considering future use of vacuum filter for dewatering municipal wastewater sludges.

Francis T. Mayo, Director
Municipal Environmental Research
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ABSTRACT

A side-by-side comparison of a conventional bottom-feed vacuum filter and a prototype top-feed vacuum filter was conducted. Thickened, waste-activated sludge at approximately 1.8 percent feed solids concentration and conditioned with ferric chloride was dewatered on two filters 12 ft (3.66 m) in diameter and 16 ft (4.88 m) long. One operated in the bottom-feed mode and the other in the top-feed mode. The filters were housed in the Filter House at the Jones Island Wastewater Treatment Plant of the Milwaukee Metropolitan Sewerage District (MMSD). As expected, the top feed filter was more efficient when forming a filter cake because of its basic design configuration (resulting in a longer drying time even at similar cycle times). The results of a statistical analysis (two-tailed t-test with a 95-percent confidence interval) of data from the top- and bottom-feed filters during operation at an equivalent loading rate (1.5 lb/hr per ft² (7.3 kg/hr per m²) and cycle time (3 minutes and 40 seconds) indicates that the difference between the average cake solids was statistically significant and that the top-feed filter produced a drier filter cake than the bottom-feed filter (15.0 versus 14.4 percent). An increase in cycle time to 4 minutes did not produce any significant increase in cake solids from the top-feed filter. But increasing the cycle time to 4 minutes did produce an increase in cake solids from the bottom-feed filter, and the resulting cake solids were comparable with those from the top feed filter.

Chemical conditioning studies using similar flocculation facilities located adjacent to each experimental filter indicated that there is no significant difference between the chemical dosages required to operate the top- and bottom feed filters at optimum levels. The dewatering mechanisms of conditioned sludge appeared to be a function of the rigidity of the floc particles and the porosity of the filter cake instead of filter design configuration. Local sludge conditioning (ferric chloride conditioning done adjacent to experimental filters) produced drier filter cakes at higher solids yields than centralized sludge conditioning done by MMSD at the acid house. Shear forces in sludge distribution lines appear to have adverse effects on floc particle structure. When such sludge is filtered, the sheared floc particles reduce filter cake porosity by filling in the voids between the larger floc particles.

Based on the data obtained during filter operation with local conditioning, the optimum conditioned sludge pH appears to be between 3.5 and 3.8. This pH range is recommended under conditions when proper mixing of ferric chloride with feed sludge has been achieved.

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Capital costs for the top-feed filter are lower than those for the bottom-feed filter (\$15,350 versus \$22,400 per filter), but maintenance costs for the top-feed filter are higher (\$1,120 versus \$154 per year per filter). A total cost comparison based on the above amortized costs indicates that there is no significant cost difference between the two filters (\$2,682 per year per filter for the top-feed filter versus \$2,434 for the bottom-feed filter.

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This report was submitted in fulfillment of Grant No. S800969 by the Milwaukee Metropolitan Sewerage District under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers a period from June 1973 to September 1980, and work was completed as of April 1981.

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SECTION 1

INTRODUCTION

This project evaluates the effectiveness of a top-feed vacuum filter on a prototype basis and compares its performance and cost with that of a conventional bottom-feed vacuum filter. This study evolved from work done under EPA Grant No. 71-01-68, which studied the performance of a pilot-scale, top-feed vacuum filter (1). The results from the pilot-scale study indicated that a top-feed vacuum filter would increase the sludge dewatering capacity of each filter, produce a drier sludge cake, and use less ferric chloride than a conventional bottom-feed vacuum filter. A significant drawback of the pilot-scale study was that no statistically valid comparison could be made between the pilot-scale, top-feed vacuum filter and the full-scale, conventional bottom-feed vacuum filter. Because of a significant difference in filter size, the pilot-scale, top-feed vacuum filter performance could not be statistically compared with that of the conventional full-scale, bottom-feed vacuum filter. The pilot-scale, top-feed vacuum filter was 6 ft (1.83 m) long by 4 ft (1.22 m) in diameter. Furthermore, comparison of the pilot-scale top-feed and bottom-feed filters was difficult because the same pilot-scale filter was used for both the top and bottom-feed mode. Thus no simultaneous operation of an equivalently sized top and bottom-feed vacuum filter was possible.

Given the promising results from the pilot-scale top-feed filter and the need to evaluate this concept statistically, a full-scale evaluation was undertaken of a top-feed vacuum filter for dewatering waste-activated sludge.

A major problem encountered during the pilot-scale evaluation of the top-feed filter was the design of seals between the top feed hopper and filter drum. During the evaluation of the pilot-scale top-feed vacuum filter, several hopper seal designs were tested to determine their capacity to provide a leak-proof seal for extended periods of time. The seals were also evaluated on their ability to withstand the acidic environment associated with waste-activated sludge conditioned with ferric chloride. Based on this evaluation, a new seal was designed. The full-scale sludge hopper design and sludge feed configuration was also based on the results of the pilot-scale experiment. For a detailed discussion of the full-scale top-feed vacuum filter design, see Section 4.

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The operation test plan for the evaluation of the top feed vacuum filter and bottom feed vacuum filter consists of four operation modes:

1. Equivalent form time and cycle time on the top- and bottom-feed vacuum filters.
2. Equivalent solids loading rate on the top- and bottom-feed vacuum filters.
3. Constant solids loading rate on the top- and bottom-feed vacuum filters.
4. Optimization of sludge conditioning pH and comparison of filtering characteristics of Milwaukee Metropolitan Sewage District (MMSD) conditioned sludge and locally conditioned sludge.

The performances of the top- and bottom-feed vacuum filters during each of these operation modes were evaluated using the performance variables: filter yield, filter cake solids, filtrate suspended solids, various operating variables such as cycle time, pickup time, and ferric chloride dosage were also monitored. A complete description of all the process parameters used to evaluate and compare performance of the filters may be found in Section 5.

The full-scale evaluation of top-feed vacuum filtration for dewatering waste activated sludge was accomplished during the periods of June 26, 1979, to September 24, 1979, and February 13, 1980, to August 7, 1980. The evaluation involved operating 7 days a week, 24-hours a day, with shutdown limited to maintenance work and routine filter washings. A detailed description of the operation test plan for these two periods is presented in Section 6.

A discussion of the results from the side-by-side comparison of the top- and bottom-feed vacuum filters is presented in Section 7. This section includes a description of seasonal variations of sludge, their impact on dewatering characteristics, and a statistically valid comparison of the top-feed and bottom-feed vacuum filter performance variables.

A cost-benefit analysis of the top-feed filter is given in Section 8. An overall discussion of the economic, design, and operational aspects of the top-feed filter is presented in Section 9.

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SECTION 2

CONCLUSION

The following conclusions can be made regarding the comparison of the top and bottom feed filters based on data from this study:

1. The top-feed vacuum filter was consistently found to be more efficient in forming a filter cake from conditioned, waste-activated sludge than the bottom-feed vacuum filter (based on lower pickup times for similar solids loadings to the experimental filters). This result was expected, since the basic design configuration of the top-feed vacuum filter makes available more of the driving force of the applied vacuum for filter cake formation.
2. The results of a statistical analysis (two-tailed t-test with a 95 percent confidence interval) of data from the two filters during operation at an equivalent loading rate (1.5 lb/hr/ft²) and cycle time (3 minutes and 40 seconds) indicates that the difference between the average cake solids was statistically significant. Thus the top-feed filter produced a drier filter cake than the bottom-feed filter (15.0 versus 14.4 percent). Further increase in cycle time to 4 minutes did not produce any significant increase in cake solids from the top-feed filter. But increasing the cycle time to 4 minutes did produce an increase in cake solids from the bottom feed filter, and the resulting cake solids were comparable with those from the top-feed filter.
3. The ferric chloride dosages required for optimum chemical conditioning for the two experimental filters were found to be similar.
4. Local sludge conditioning (ferric chloride conditioning done adjacent to experimental filters) produces drier filter cakes of equivalent or higher solids yields than centralized sludge conditioning done by the MMSD at the acid house. The shear forces in the pipeline network from the acid house appear to be responsible for disrupting floc particles and reducing the dewaterability of the filter cake.
5. Based on the data collected during filter operation with local conditioning, the optimum conditioned sludge pH appears to be between 3.5 and 3.8. This pH range should not be considered as absolute because the length of mixing time between addition of ferric chloride and pH measurement will have a significant impact

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on observed pH. The ferric chloride dose (pounds ferric chloride/ton dry solids) should also be considered when determining the optimum conditioning level because the quantity of ferric chloride required to obtain a given pH will vary from day to day.

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6. Seasonal variations in sludge characteristics did not substantially affect the performance of the two experimental filters relative to each other. Certain seasonal variations in sludge characteristics were observed during this study, however. The ferric chloride required for optimum sludge conditioning decreased from an average of 170 lb ferric chloride/ton dry solids (85 kg ferric chloride/metric ton) in the summer and fall months of 1979 to an average of 80 lb ferric chloride/ton dry solids (40 kg chloride/metric ton) in the early months of 1980. Another variation in sludge characteristics was an increase in sludge temperature from 12 °C in the winter months to 24 °C in the summer months. The higher summer sludge temperatures appeared to have a detrimental effect on filter performance by promoting a considerably greater growth rate of the slime associated with filter blinding.
7. Filter cake discharge from the top-feed filter requires little assistance from the scraper blade in the first 2 or 3 days of the filter operating cycle, but continued operation beyond this time will require the scraper blade to initiate cake discharge at the leading edge of each panel. Gravity will then peel the filter cake to the trailing edge of the panel. Blinding, which usually starts at each division strip, disrupts the continuity of the filter cake between the trailing edge of one panel and the leading edge of the next panel.
8. The key to successful operation of the top-feed filter is the effectiveness and life of the hopper seals. The effective operating life of the extruded seal on the top-feed filter was observed to be approximately 6 months. Replacement at this interval will ensure optimum performance from the top-feed filter. The polyolefin wear sheet along the horizontal edge of the top-feed seal has an effective life of 2 months. A 0.03 in. (0.76 mm) thick wear sheet was found to be quite effective in reducing leakage.
9. Analysis of the unique maintenance costs pertinent to the individual experimental filters show the top-feed filter capital costs to be lower than the bottom-feed filter (\$15,300 versus \$22,400 per filter), but the maintenance costs of the top-feed filter are significantly higher (\$1,120 versus \$154 per year per filter). A total cost comparison based on the above estimates that there is no difference between the top-feed and bottom-feed filter costs (\$2,682 versus \$2,434 per year per filter, respectively). These values are based on analyses of the operating and capital costs that are unique to each filter. Any operating

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or capital cost common to both filters (such as the cost of the filter drum) were not included in the cost analyses. The net costs are amortized over a 20-yr basis at an 8-percent interest rate.

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SECTION 3

RECOMMENDATIONS

It is recommended:

1. More work should be devoted to developing a seal and wear sheet that has a longer life and provides better sealing properties.
2. That top-feed filter performance should be evaluated for sludges other than waste-activated sludge. The performance of the prototype top-feed filter was evaluated using one of the most difficult municipal sludges to dewater--waste-activated sludge (WAS). This sludge is difficult to dewater because of its hydrophilic nature. The overall evaluation of the prototype top-feed filter has indicated that its performance was slightly better or comparable with the bottom-feed filter for conditioned WAS. The top-feed filter's relatively high yield and shorter cycle time indicate that such a filter configuration might perform significantly better on other types of sludges. Some of the other sludges for which evaluation of the top-feed filter configuration may be used are anaerobically digested sludges, sludges treated with alum (for phosphate removal), and other industrial sludges.

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SECTION 4

TOP FEED FILTER DESIGN CONSIDERATIONS

BACKGROUND PILOT FILTER PROJECT

Top feed filter pilot scale test operations were performed in 1970 under the provisions of Grand no. WPRD 71-01-68. Testing was performed on a 4 ft (1.22m) diameter by 6 ft (1.83m) long vacuum filter provided by the Milwaukee Metropolitan Sewerage District (MMSD). Construction and maintenance duties were performed by the District, while Rexnord (then Rex Chainbelt) operated the filters, collected and analyzed the data, and wrote the necessary reports.

It was found from the pilot filter program that by dewatering sludge on a "top feed" filter, the following advantages could be gained:

1. Sludge dewatering capacity per machine could be increased.
2. Drier sludge cake could be produced.
3. Less ferric chloride was required to condition the sludge.

The only disadvantage appeared to be problems associated with sealing the top feed hopper to the top of the vacuum filter drum.

The original pilot scale hopper was designed to accept seals of various designs. Three basic peripheral seal designs were tried and are shown in Figure 1. The most successful pilot filter seal was the third seal, with an "X" cross section. It was made of molded rubber and worked well, except that it did not have a long wear life.

The brush seal worked well until the filter was shut down. Sludge solids within the bristles hardened upon drying, thereby rendering the seal unsatisfactory. A seal with a "Y" configuration was also tried. Friction drag on the sealing edges caused the seal to buckle and lift off of the drum surface, allowing sludge to leak out.

A second hopper was built with a "humpback" shape (Figure 2) and provisions for mounting a new "X" shape seal. The humpback shape was intended to reduce the volume of sludge supported by the vacuum filter, and to eliminate the supernatant pocket that formed in the hopper.

The major disadvantage of the humpback hopper was that the horizontal seal was inaccessible from inside of the hopper. Clean-up was also difficult. Experience with these designs provided the basis for design of the full-

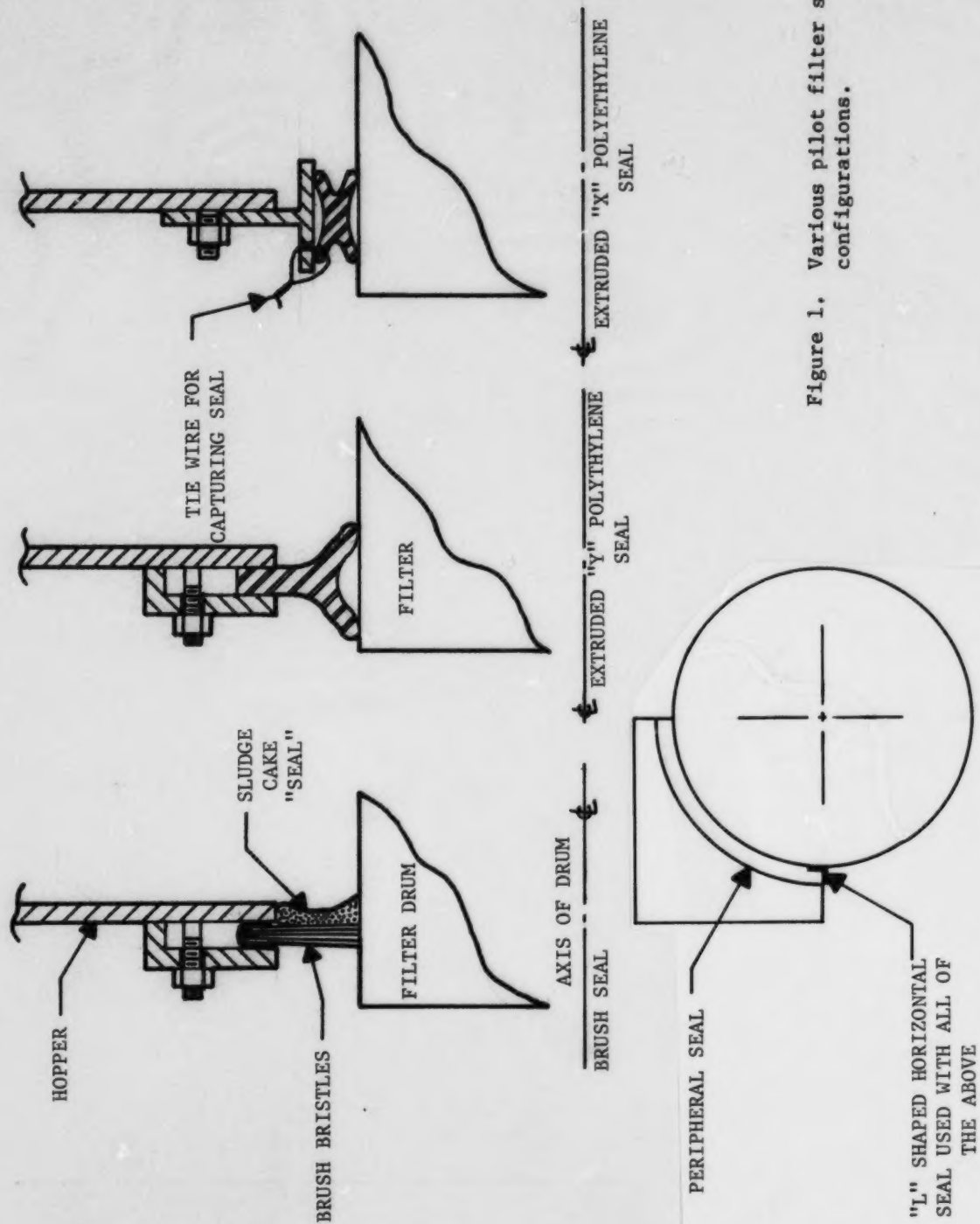


Figure 1. Various pilot filter seal configurations.

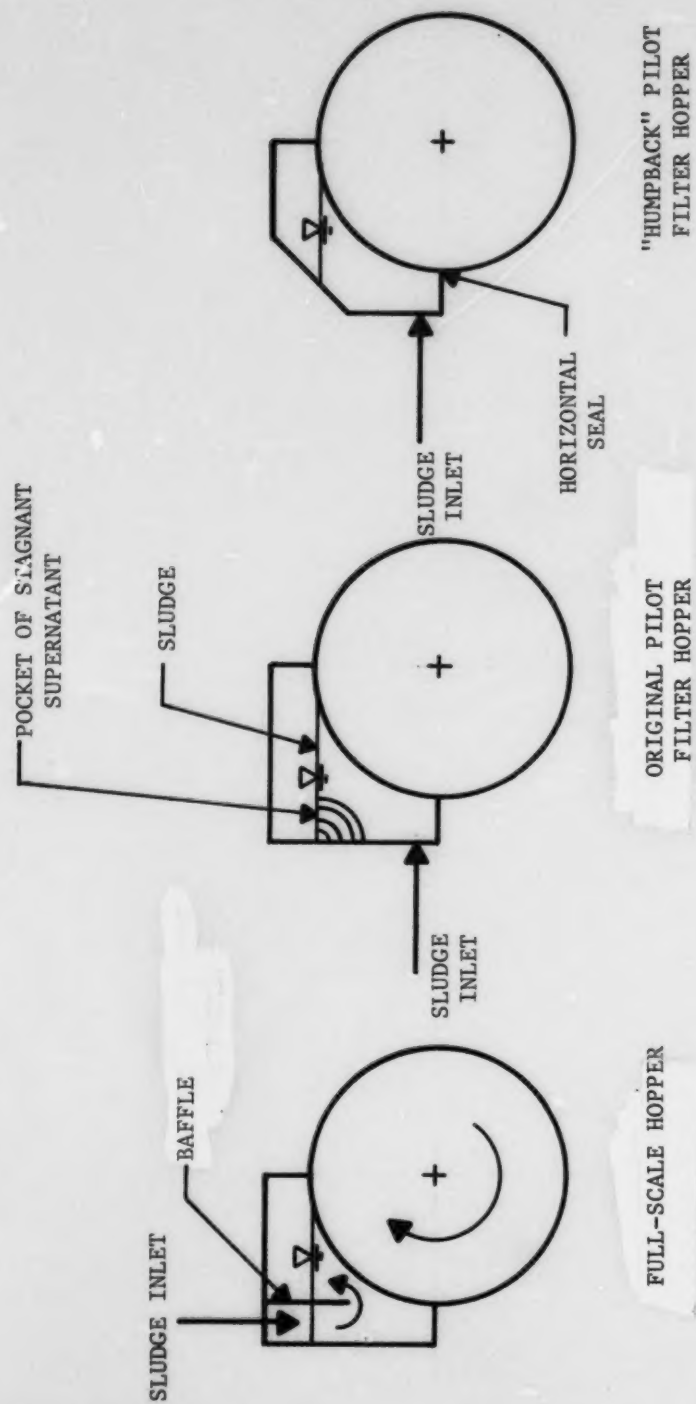


Figure 2. Various top feed filter hoppers.

scale top feed hopper. As shown in the first sketch in Figure 2, a full-scale hopper should provide access to the horizontal seal and a means to circulate the sludge.

Seal evolution continued with the trial of the "X" seal, (Figure 1). The seal was about 1.0 in. (2.54 cm) high when full, and was compressed to about 0.5 in. (1.27 cm) when installed. This preload compensated for the buckling problem exhibited by the "Y" seal, and seal problems appeared to be solved. With use, however, the seal material became brittle and the "X" seal began to leak in a manner similar to the "Y" seal. Fortunately, the "X" seal did last long enough to complete the pilot scale program and gather process data.

FULL SCALE DESIGN DATA FROM THE PILOT FILTER PROGRAM

After completion of the pilot scale top feed filter study, it became evident that certain design aspects would require consideration to assure development of a successful full-scale program. The following discussion elaborates on these aspects:

1. The seal is the most critical problem to be solved. The seal must have a low profile about the thickness axis and a long profile about the width axis. The seal should be like a strap-flexible in one direction, stiff in the other direction.
2. Seal material should be resistant to chemical attack and the resulting embrittlement. If a material with permanent resiliency cannot be used, means to adjust pressure on the seal mechanically should be provided.
3. The "L" shaped horizontal seal worked well, but other material selections should be studied to find a longer lasting, wear resistant material.
4. Due to the limited flexibility of the hopper seals the full scale sludge hopper must resist deflection. The seal mounting surface on the sludge hopper and the drum surface must be aligned to within low tolerance limits (as discussed in the following design section).
5. Because the sludge is contained in a hopper high on the filter, sludge piping must be carefully designed with minimum headloss to assure adequate sludge supply to the filter.
6. Since sludge cake is discharged low on the filter, the filter may require elevating to assure adequate discharge chute slope. A steep slope is required to transfer the discharged sludge cake to the conveyor and eliminate sludge cake buildup on the discharge chute. The chute must also be well below the scraper blade to prevent solids sludge cake from falling below the filter. Premature cake discharge can occur when air blow-off is used.

7. The use of air pressure to assist cake discharge was unnecessary most of the time. When it was required, considerable filtrate "blow-back" resulted. The rotary valve timing and vacuum piping should be designed to maximize removal of filtrate from the panels. Installation of traps in filtrate lines would also reduce the quantity of filtrate discharged with air blow-off.

FULL-SCALE TOP FEED FILTER DESIGN

The full-scale top feed filter system was designed in accordance with the experience gained from the pilot filter program. The following solutions were found for the problems identified during the pilot filter program:

1. An extruded seal with a cross section as shown in Figure 3 was designed to meet the criteria of stiffness in the width direction, flexibility in the thickness direction. This seal has provision for mounting and the top groove serves to trap a tension wire which can be tightened to apply additional sealing pressure.

The seal material chosen was a copolymer of polyethylene and polypropylene plastic mixture, with a slip agent added to reduce sliding friction. This material exhibited good wear resistance and did not deteriorate due to chemical attack. Although the seal size was limited by the extruding machinery, the cost was the lowest of the four vendors who quoted on the seal. A wider seal would have been more desirable, however, this seal was considered to be adequate.

2. Since the extruded seal extends across the bottom of the hopper, as well as up the sides (see Figure 3), the "L" seal (wear sheet) is required to seal the horizontal part of the hopper. The "L" seal (wear sheet) provides a smooth surface to distribute the extended seal force. The added area acts as a lip to seal the media cloth joint as it passes into the hopper.

The material selected for the "L" seal (wear sheet) is High Molecular Weight (HMW) 1900 polyolefin. It has a very low coefficient of friction, long wear life, and high chemical resistance.

3. Because of limited seal flexure, the hopper seal mounting must be held to close tolerances. The curved and straight mount surface tolerances were limited to $\pm 1/16$ inch (1.6 mm). The flexural deflection across the hopper back was limited to $1/8$ inch (3.2 mm) when the hopper is full of sludge. A heavy box beam welded to the hopper frame provides the necessary stiffness.
4. Sludge pipe was sized at 8 in. (20.3 cm) to allow adequate flow velocity. Adequate head to force the sludge to the filter at the required flow was assumed by mounting the experimental filter at the low elevation of the existing production filters.

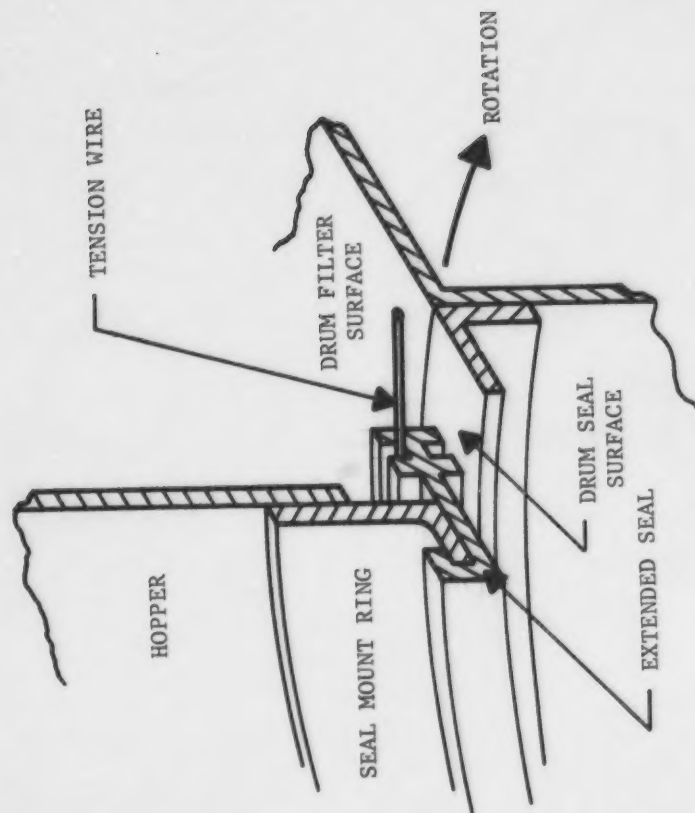


Figure 3. Full-scale seal configuration.

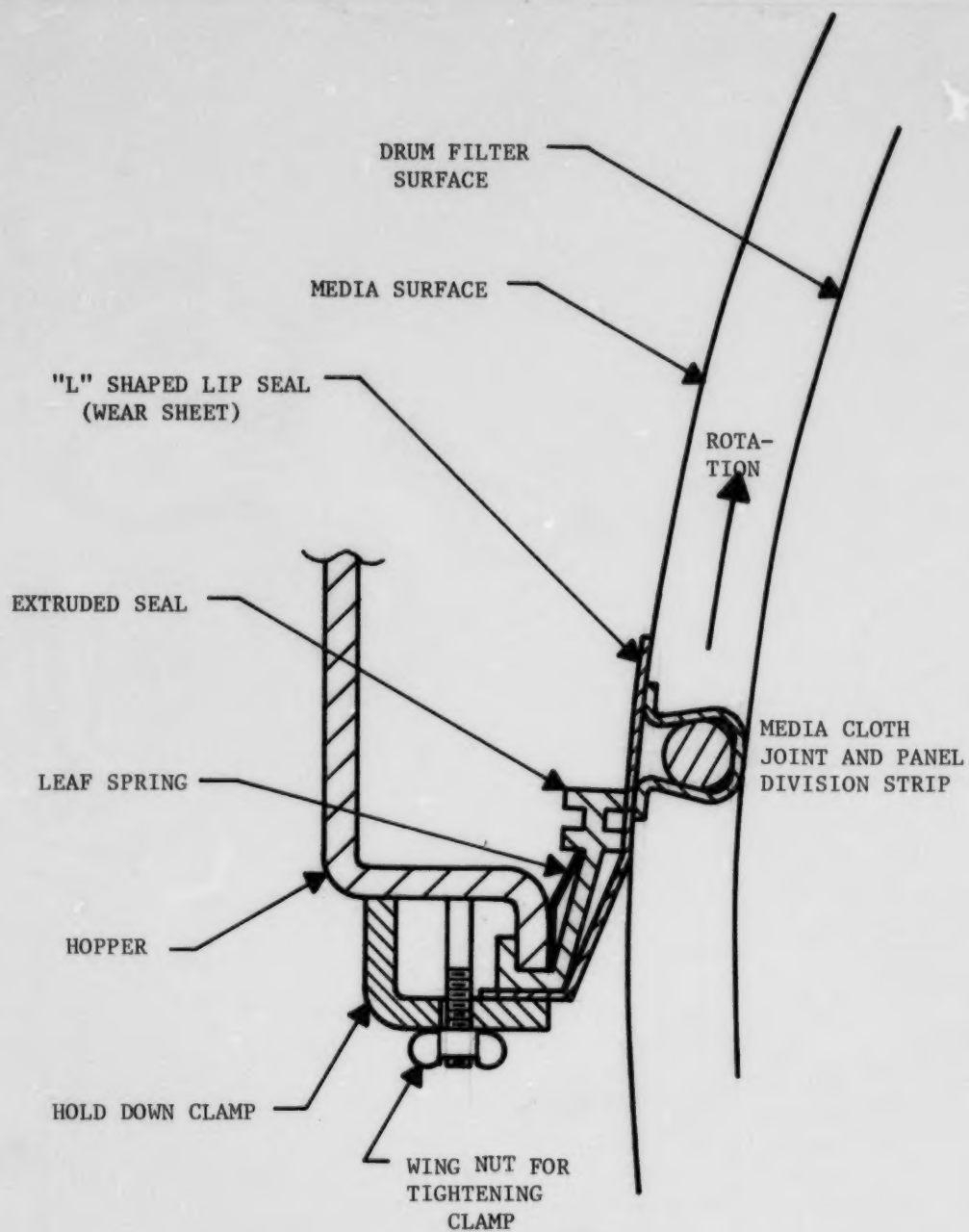


Figure 3 (continued).

5. The sludge cake conveyor was located close to the floor to maintain an adequate chute slope. This allowed a chute slope of 45° from the discharge point to the conveyor belt. Although marginal, this slope proved to be adequate for discharge. Elevating the top feed filter was not necessary.
6. To reduce or eliminate filtrate "blow-back", the filter panel drain piping was separated and two rotary valves were provided. One valve controls the leading edge drain piping, the other controls the trailing edge drain piping. As a panel rotates below the horizontal centerline of the filter drum, the leading edge piping is open to vacuum. As the panel rotates upward past the vertical centerline of the drum, the trailing edge piping is open to vacuum. Thus, by applying vacuum at the lowest point of each panel, the maximum amount of filtrate is removed.

TOP FEED SUPPORT EQUIPMENT

To compare the top feed filter operation with a conventional bottom feed filter, all physical variations between the two machines were eliminated or reduced. The only difference between the machines was to be the method of applying sludge. Both machines were provided with identical support systems. Each part of the support system is discussed here:

1. Sludge supply - Conditioned sludge from the "acid house" (hereafter referred to as MMSD conditioned sludge) was piped to each filter from an extension on the production filter pipeline. Each experimental filter was thus supplied with the same conditioned sludge as the production filter. The piping to each experimental filter was kept identical with respect to size, type, and number of fittings. (Due to extended height, the top feed filter piping was slightly longer).

A pipeline from the "acid house" was built to carry unconditioned sludge (no ferric chloride added) to the point where the production filter sludge supply was tapped. Valves in both pipelines allow the selection of conditioned or unconditioned sludge. The unconditioned sludge was piped to a mixing and flocculation tank furnished for each filter, Figure 4.

As the unconditioned sludge flowed through the flocculation tanks, ferric chloride was added to the sludge and mixed by air spargers. Baffles in each tank routed the flow in serpentine fashion to assist in the mixing. As the sludge flowed toward the tank outlet, flocculation occurred. This conditioned sludge then flowed by gravity to each experimental filter.

The flocculation tanks were required to study the effects of varying the addition rate of ferric chloride on dewatering.

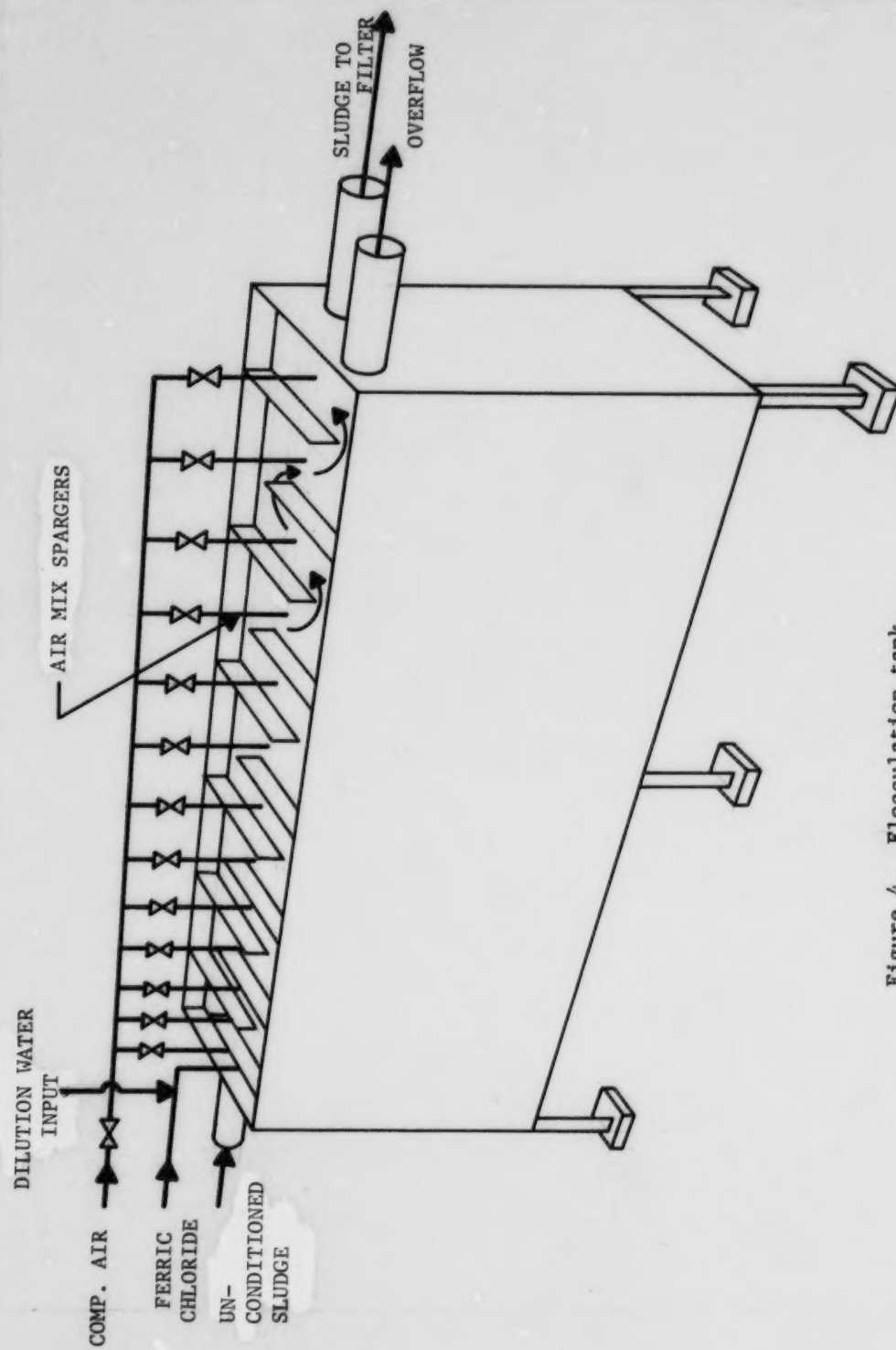


Figure 4. Flocculation tank.

Having separate flocculation tanks allowed the variations of ferric chloride dose to each filter independently without affecting the plant operation.

2. Filtrate collection - The filtrate from each experimental filter was piped to a 300-gal. (1,140 liter), rubber lined filtrate receiver tank. Plant vacuum was connected to the top of each filtrate receiver to remove the air. A filtrate pump having a high suction capacity removed filtrate from the bottom of each filtrate receiver. Filtrate was pumped up to the filter deck floor drain pipes where it flowed by gravity to the cake breaker tank. The filtrate receivers and filtrate pumps were required to allow measurement of filtrate flow.

3. Dewatered sludge conveyors - A belt type conveyor was provided to remove discharged filter cake from the filter area. Both filters discharged onto a "primary" conveyor. A "secondary" conveyor located below the primary conveyor discharge end carried the filter cake at an incline to discharge onto the plant's main belt conveyor.

The secondary conveyor was fitted with a reversing starter. When the experimental filters were being started up and the dryers were not ready to accept the sludge, the secondary conveyor could be reversed. Sludge cake on the secondary belt discharged into a "cake breaker" tank located under the conveyor trail pulley. A mixer in the cake breaker tank chopped up the sludge cake so it could be recycled back to the head end of the plant.

4. Chemical feed system - Two positive displacement chemical pumps driven by one motor were furnished to supply ferric chloride to the flocculators. Each pump had electric stroke control to vary the chemical pumping rate. Two 700-gal. day/ (2,650-liter/day) tanks as reservoirs to pump from. The operator filled each tank from the plant ferric chloride supply whenever the tank level was low. By periodically measuring the tank levels, ferric chloride consumption could be calculated. River water was injected into the chemical pipes downstream from the chemical pumps to aid in dispersing the ferric chloride into the sludge. Rotameters were used to measure the amount of dilution water used.

5. Instrumentation and control - The following instrumentation and control was provided:

- a. Sludge flow meter - Magnetic flow meters were used to measure sludge flow to each filter. A two-pen recorder indicated and recorded the instantaneous flow while counters indicated the total gallons processed by each filter.
- b. Filtrate flow meter - Filtrate flowing from each filtrate pump was measured by vortex shedding flow meters. A

two-pen recorder and counters indicated and recorded the instantaneous and total flows, respectively.

- c. pH meters - Each flocculation tank was furnished with a pH meter. A two-pen recorder recorded the variations of pH with time for each filter system.
- d. Chemical pump control - A proportional controller was furnished for each filter system to automatically control the ferric chloride pump output. The controllers were selected to accept signals from either the pH systems or the sludge flow meters. If operating on pH, the controllers increased the flow of ferric chloride to reduce pH when pH began to rise. When operating on flow, the controllers were set on manual operation to allow the operator to increase or decrease ferric chloride flow in proportion to flow. The operator then maintained a constant pH.
- e. Filtrate level - Float switches located on the filtrate receiver tanks were furnished to stop the filter drums and sound the alarm if the filtrate level rose to fill the tanks. This alarm was intended to prevent filtrate from filling the filtrate tanks and entering the vacuum system.
- f. Sludge level control - Sludge level in the top feed hopper and the bottom feed vat was controlled by pneumatic controllers. Each controller sensed the back pressure on bubbler tubes immersed in the sludge. As sludge level went down, the controllers sensed a lower back pressure. The controllers then signalled the sludge flow control valves to open, thereby raising the sludge level to the set-point value. The controllers closed the sludge valves when level increased above the set-point values. The level control systems, including the bubbler purge-meters, controllers, and flow control valve were pneumatically operated.
- g. Vacuum flow meters - Air flow in the vacuum pipes was measured by a differential pressure device similar to a pitot tube. Temperature gages and pressure gages installed in the vacuum pipes were used to measure temperature and vacuum pressure. The three variables were then used to calculate air flow in actual cubic feet per minute (ACFM).

SECTION 5

VACUUM FILTRATION PROCESS PARAMETERS

Vacuum filtration is a commonly used process to dewater the sludges produced while removing suspended materials from wastewater streams. The Milwaukee Metropolitan Sewerage District (MMSD) Jones Island Wastewater Treatment Plant produces only gravity thickened waste activated sludge, which is conditioned with ferric chloride prior to dewatering. In order to fully understand the discussion of the data from this study a description of the vacuum filtration process parameters will be presented below. A glossary of terms used in this report is presented in Section 11.

Vacuum filtration uses a driving force of a pressure differential across a media (in this case dacron cloth) to separate the liquid phase of sludge from the solid phase. The solid phase of waste activated sludge consists primarily of biological material which may approach a 90 percent organic content. Applying a vacuum to this unconditioned activated sludge would result in a layering of the microorganisms present in the sludge. As these layers compact under the applied vacuum, the porosity of the cake is reduced to zero and no water can be removed from the sludge cake (2). This problem is referred to as blinding. (Blinding of the filter may also occur from slime growth in the filter cloth and from compaction of filter cake within the weave of the filter cloth where the nap has been worn away).

To avoid blinding of the vacuum filters during dewatering of thickened waste activated sludge (WAS) a conditioning chemical is added. In this case a polyvalent metal, Fe(III), in the form of FeCl_3 is added to the thickened WAS. The FeCl_3 is mixed with water before being added to the thickened WAS to aid in dispersing the ferric iron. The WAS and FeCl_3 solution are then mixed using compressed air. The ferric ion when mixed with the thickened WAS forms charged polymeric species (hydroxo-iron polymers) that form bridges between the sludge particles. Many of the microorganisms in the thickened WAS will produce extracellular polysaccharides that will induce flocculation. This naturally induced flocculation, however, is not amenable to dewatering through vacuum filtration (2).

The formation of this fibrous structure (large floc particle) with a relatively high porosity

The fibrous structure of hydroxo-iron polymers and sludge particles form a rigid and porous structure when the filter cake is initially formed during the pickup phase of vacuum filtration. The filter cake will then allow water to pass through it with a minimum headloss, thus facilitating

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rapid dewatering during the drying phase of the dewatering cycle. As the filter drum nears the end of the drying phase the flow of filtrate ceases and only air flows through the filter cake voids. At this point any further reduction in cake moisture will be due to evaporation.

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The kinetics of dewatering thickened WAS is governed by several interacting process parameters which can be adjusted to improve the dewatering characteristics.

The process parameters and the relationships between these parameters are illustrated in Figure 5. These parameters are divided into two groups; operating parameters and response parameters. The operating parameters, cycle time, pickup time, dry time, vacuum level, sludge conditioning, solids loading, and the filter cloth all interact to provide the optimum operating state which is reflected by the response parameters, filter cake solids, solids yield, filtrate suspended solids, filter cake discharge, and filter cloth blinding. As indicated by Figure 5, the process parameters have many relationships and it is the sum of these relationships which determines the effectiveness of the vacuum filtration process. A discussion of these relationships is presented below.

The filter medium used on both the top feed and bottom feed vacuum filter was 8 oz (227 gram) napped dacron cloth. This cloth was used on all the production filters at the Jones Island plant and has a relatively long filtration life. This type of cloth has been found to be well suited for producing the type of cake necessary for the subsequent drying operation. No attempt was made in this study to determine the impact of various types of filter cloths on the relative performance of the top feed and bottom feed filters. However, it should be stated that different filter cloths will have different filtration characteristics. The presence of nap on the surface of the filter cloth is very important to the cloth performance. The nap prevents the sludge cake from penetrating the weave of the cloth thus aiding discharge of the filter cake. If the filter cake does penetrate the weave the cake will not discharge and blinding will occur. Air blow-off, which involves the use of pressurized air to separate the filter cake from filter cloth, will reduce this type of blinding, but filtrate is also blown out of the filter, consequently reducing the filter cake solids.

Slime growth around the fibers of the filter cloth will also cause blinding of the filter cloth. The slime grows throughout the weave and forms an impermeable layer which can only be broken by chemical (HCL) or physical agitation (high pressure water sprays). This slime is usually more prevalent during the summer months than during the winter months when the relatively warm sludge temperature and warm air temperature increase its growth rate. Sludge temperatures at the Jones Island plant increased from 12 °C in late February to 24 °C in August. Periodic washings of the filters with high pressure water sprays will reduce the amount of slime growth, but it does not remove all the growth. After a period of time that may vary from 2 weeks to 3 to 4 months, depending on sludge temperature and filter performance the filter requires washing with concentrated hydrochloric acid. Each filter is cleaned by running 140 lb (64 kg) of acid over the cloth and then allowing the filter cloth to soak for three

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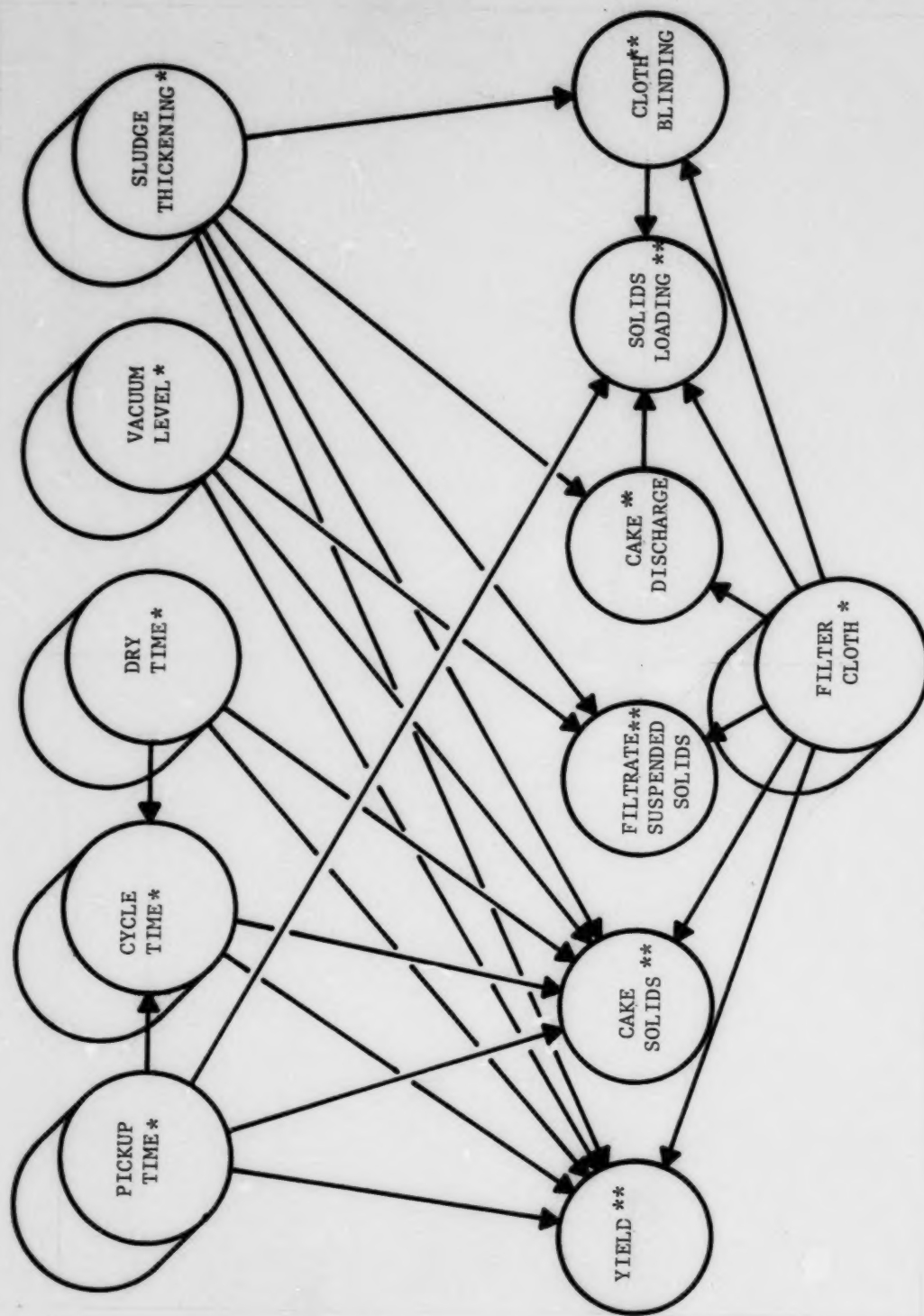


Figure 5. Relationship of vacuum filter process parameters.

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to four hours. This technique will restore most of the blinded sections of the filter cloth to useful service.

The position of the scraper blade relative to the surface of the filter will also influence the amount of blinding and consequently filter performance. If the scraper is flexible in design and is properly positioned the amount of blinding is very small. Figure 6 shows how the positioning of the scraper blade may affect the discharge of the filter cake.

When the scraper is riding on the nap of the filter cloth the cake is discharged very well. However, if the scraper blade is not in contact with the nap of the filter cloth, because of improper positioning of the scraper blade, irregularities in the scraper blade, or the drum does not have a smooth surface, the filter cake is not discharged properly. In the case of the bottom feed filter the residual filter cake is cycled around on the drum again and again is drawn into the filter cloth weave by repeated exposures to the pickup and dry vacuum. This residual cake is also a site for slime formation. The presence of organic material with no filtrate washing through it provides an excellent environment for slime growth. In the case of the top feed filter the residual filter cake is forced into the weave of the cloth by the horizontal seal as well as by the repeated exposures to the pickup dry vacuum.

The position of the scraper blade on the top feed filter can reduce the impact of blinding discussed above. Figure 7 illustrates the positioning of the top feed filter scraper blade and the bottom feed scraper blade.

The scraper blade on the top feed filter is required to initiate the discharge of the filter cake, but gravity will continue to "peel" the filter cake from the filter cloth as the drum rotates. This will reduce the amount of blinding caused by the scraper blade because the blade is not required at every point on the top feed filter to discharge the cake. However, if the sludge is not properly conditioned or slime has built up on the filter cloth, the filter cake will not discharge easily from the top feed filter (or from the bottom feed filter) and the scraper blade positioning will be critical to proper discharge of the filter cake.

The time required for one revolution of the vacuum filter drum is referred to as the cycle time. The cycle time is the sum of the timing for four zones: pickup zone, dry zone, blow-off zone, and dead zone. Figure 8 illustrates the various zones of the top and bottom feed vacuum filter. The pickup zone is that section of the drum which is submerged in the sludge. The actual pickup time varies with the cycle time and sludge depth. The bottom feed vacuum filter is designed to have a 90 ° pickup zone. However, as the sludge level is increased in the bottom feed hopper the pickup time increases.

The top feed filter can only have a maximum of 90 ° for a pickup zone. If the sludge depth is increased beyond the 90 ° pickup zone it will overflow the top of the vacuum filter. Sludge running over the top of the hopper is not dewatered very well and produces a filter cake of low solids. During the pickup time the filter cake is formed and the filtrate is drawn through the drum piping by a vacuum.

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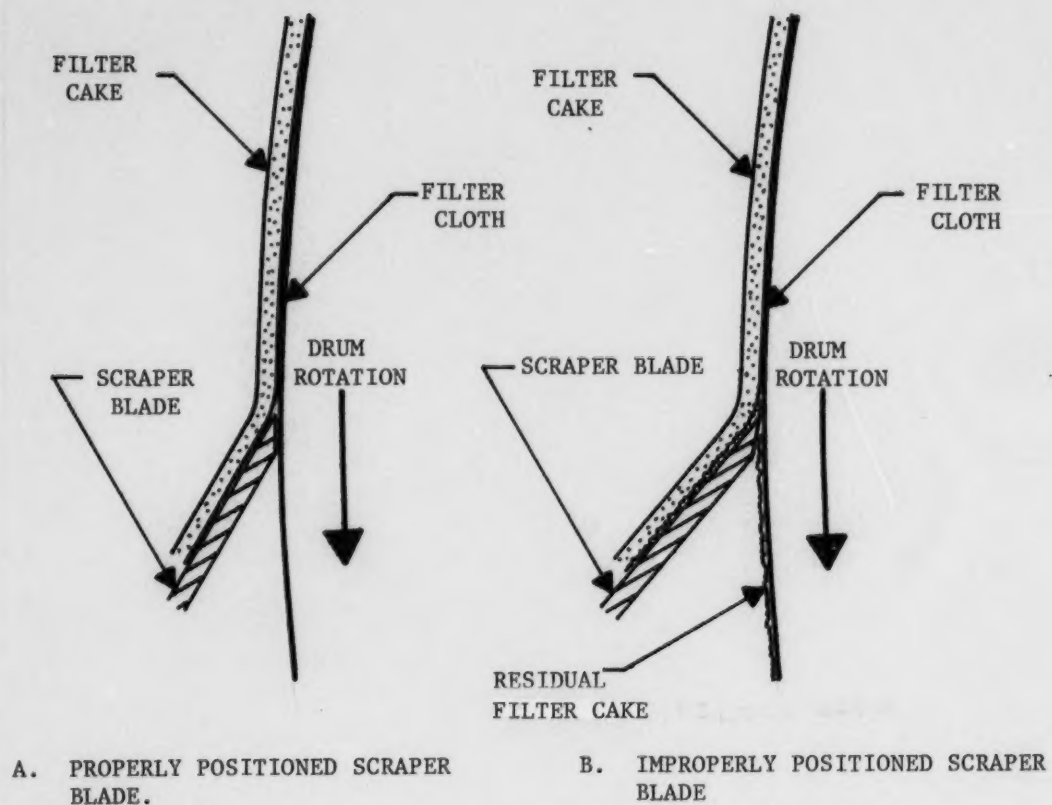


Figure 6, Impact at scraper blade position on filter cake discharge.

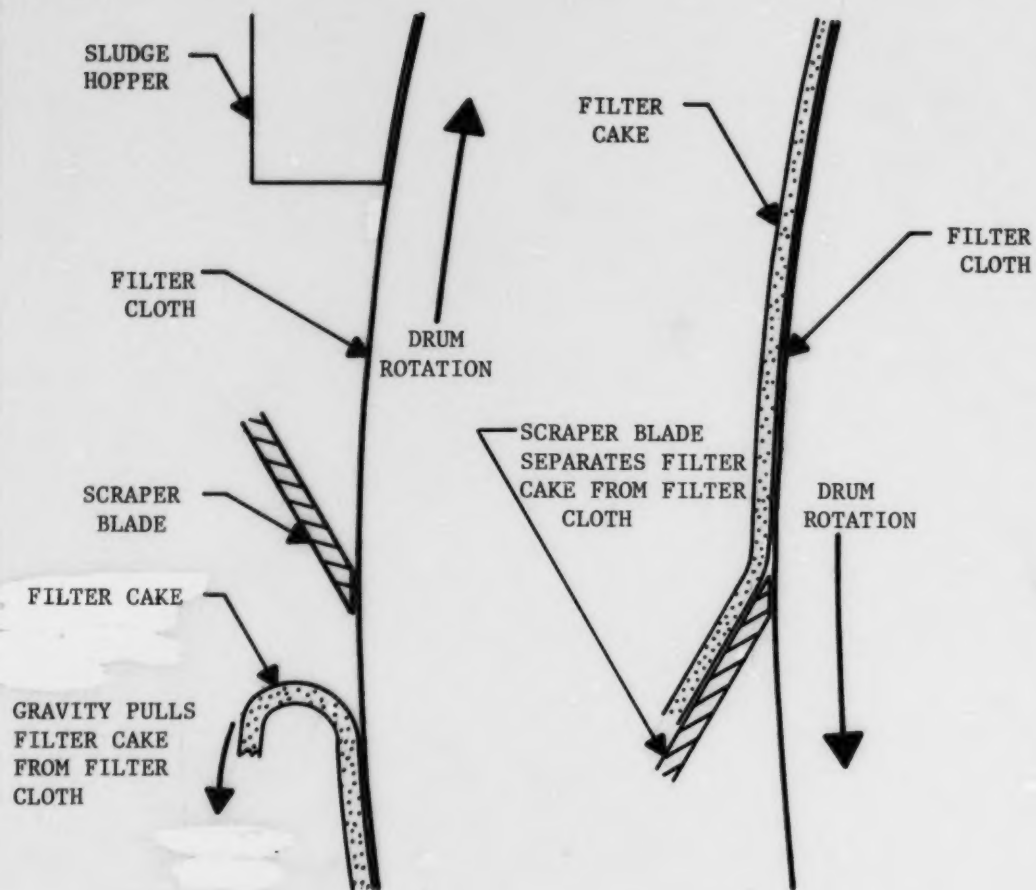


Figure 7. Filter cake discharge from top feed and bottom feed filter.

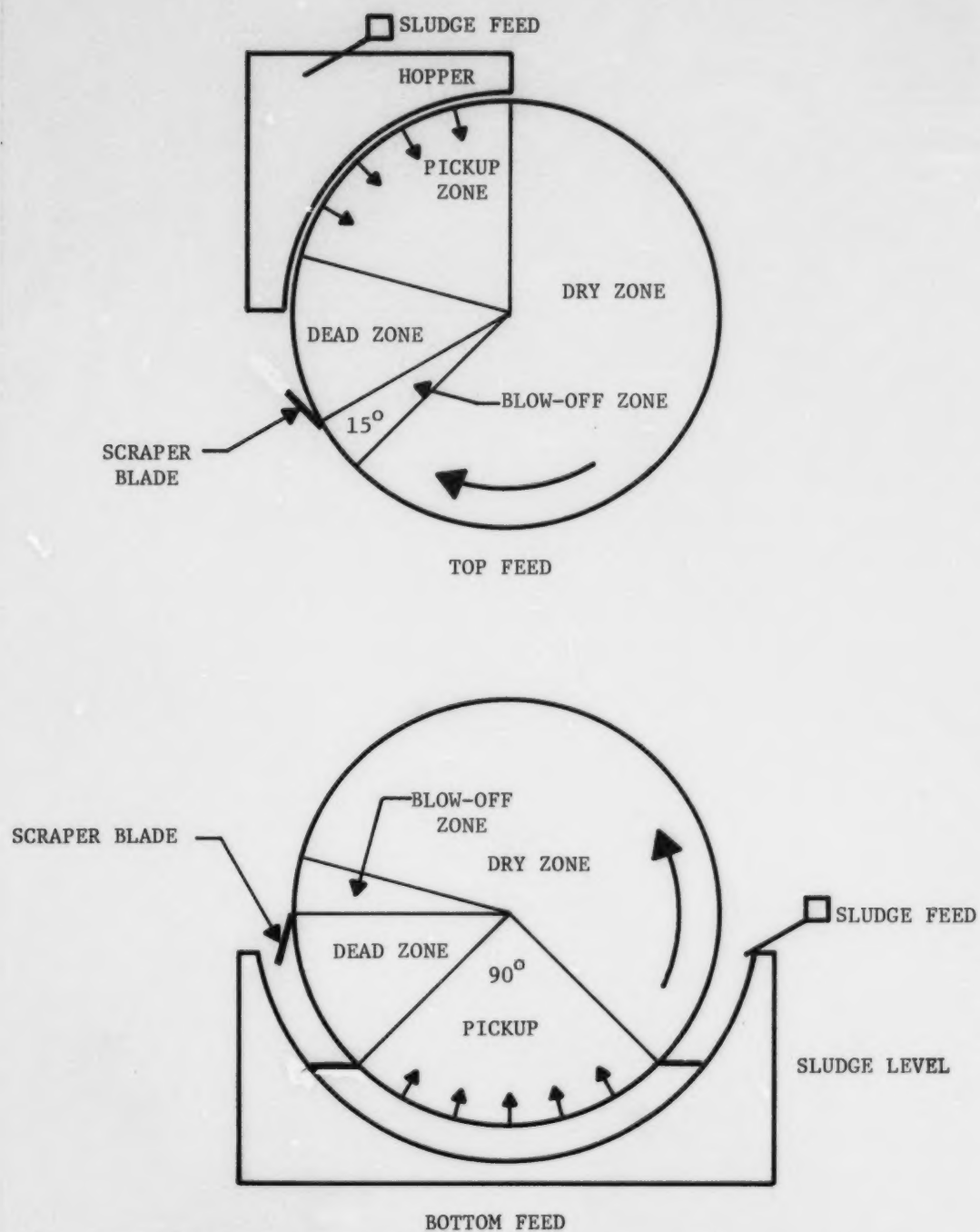


Figure 8. Difference between bottom feed and top feed vacuum filtration zones.

With the bottom feed filter the filtrate is drawn up through the filtrate pipes against gravity. The amount of hydrostatic pressure available to aid the vacuum during the pickup time is a maximum in the middle of the pickup zone and a minimum at each end. This hydrostatic pressure, however, is less than the pressure required to force the filtrate upward through the radial filtrate pipes to the filtrate pipes in the center of the drum. The filtrate pipes in the center of the drum are always at a higher elevation than the sludge level. Thus, some of the driving force in the vacuum is being used to elevate the filtrate and not to form a filter cake.

In the top feed filter the hydrostatic head of the sludge is available to aid the driving force in the vacuum and a filter cake is formed more quickly in the top feed mode. In fact, when the top feed sludge hopper (Figure 8) is filled with sludge, there is an additional head of 6 ft (1.83 m) of sludge [equivalent to 6 inches (15.2 cm) Hg] available to form a filter cake when the filter is at the bottom of the top feed sludge hopper. This additional driving force then diminishes as the filter rotates to the top of the sludge hopper.

As the filter cake leaves the pickup zone it moves into the dry zone. While in the dry zone the filter cake compresses as water in the filter cake voids is drawn out by the vacuum. In the bottom feed filter this filtrate is initially pulled against gravity, but as the filter cake rotates to the top side of the drum all the filtrate drains by gravity away from the drum surface. This situation is reversed on the top feed filter. The filtrate is initially draining by gravity in the dry zone, but as the filter cake rotates to the bottom side of the filter drum any filtrate the vacuum pipes drains toward the drum surface. This filtrate may then collect between the filter drum surface and filter cloth. As the drum rotates up to the scraper blade any filtrate will collect near the division strip and when the vacuum is released at the dead zone, this filtrate may possibly be reabsorbed by the filter cake if they are in contact. Figure 9 illustrates this situation. No filtrate is expected to be reabsorbed by the filter cake while the filter cake is under vacuum. The vacuum will be drawing air through the pore spaces in the filter cake and this would prevent any movement of filtrate back into the filter cake pore spaces.

The level of vacuum used to dewater sludge will have an impact on the filtration process. The vacuum is the driving forcing that separates the liquid and solids phases of sludge. Thus, the higher this driving force the more efficient the sludge dewatering process. There are practical limits, however, to the level of vacuum that may be used. Extremely high vacuum levels, greater than 23 inches (58.4 cm) Hg would require more costly and more powerful vacuum pumps. This higher vacuum would not significantly improve the performance of the vacuum filters but would significantly increase the cost of operation. For these reasons the top feed and bottom feed vacuum filters were operated using the Jones Island plant vacuum. There was no attempt to control the vacuum level at the experimental filters and since both experimental filters were attached to the same plant vacuum line variation in the plant vacuum did not affect the side by side comparison of the two filters.

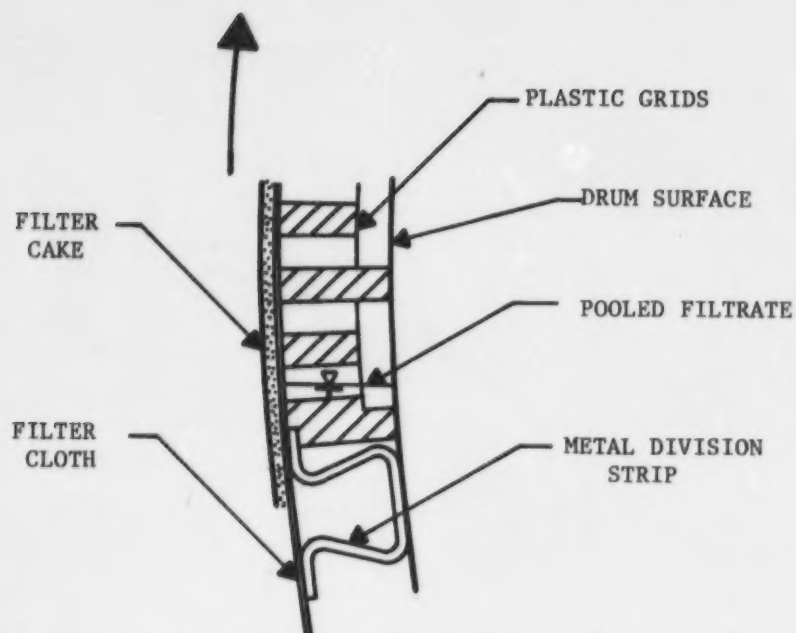


Figure 9. Filtrate pooling under filter cloth on top feed filter at the end of the dry zone.

Of the response parameter illustrated in Figure 5, the three variables that are most important in determining the efficiency of the vacuum filtration process are solids yield, filter cake solids, and filtrate suspended solids.

The filtrate suspended solids is an indication of the filter cloth wear and to some extent sludge conditioning. If the filter cloth has retained much of the nap and the sludge floc particles are rigid and do not break down during dewatering, then the filtrate suspended solids will indicate a solids recovery of greater than 99 percent. A worn filter cloth will allow larger sludge particles through and increase the suspended solids content of filtrate. A poorly flocculated sludge would contain small, loosely bound particles that could penetrate the filter cloth also reducing the filtrate quality.

The filter solids yield (usually expressed as lb dry solids/hour/sq ft of filter) is a function of pickup time (or form time), the amount of filter cloth blinding, and the sludge conditioning. The solids yield is a measure of the pounds of dry solids from a square foot of filter surface over an hour's time. A poorly conditioned sludge will not retain a rigid, porous structure and consequently filter a small volume of sludge before the filter cake is compressed to the point that the headloss through the filter cake is equal to or greater than the available vacuum.

Filter cloth blinding reduces the solids yield by reducing the area of the filter surface that is available for sludge dewatering. Cloth blinding also will reduce the filter cake solids. If each filter is

expected to produce a certain solids yield, then the solids loading on the unblinded portion of the filter surface is increased. This leads to a longer pickup time because the remaining filter surface must filter a larger volume of sludge. As a result the dry time is reduced and the thicker filter cake will dewater at a slower rate.

The response parameter, cake solids, refers to the solids content of the filter cake, and is expressed as percent of solids in the filter cake on a mass basis. As shown in Figure 5 cake solids is affected by all the operational parameters. For example, if the waste activated sludge is not conditioned with a sufficient quantity of ferric chloride, the filter cake does not dewater easily and low cake solids results. Or if too much ferric chloride is used in conditioning the activated sludge, the filter cake will "crack" and air will flow through these cracks and not through the pores of the filter cake. This will result in low cake solids because water is not being pulled from the filter cake voids. The vacuum to the drum also drops and this further reduces the cake solids.

In this study cake solids is the most important response parameter. The relative performance of the two filters will be determined by comparing the cake solids of each filter. Along with the other response parameters illustrated in Figure 5, an overall evaluation of the top feed vacuum filter will also be presented in Section 7.

SECTION 6

OPERATIONAL TEST PLAN

The objectives of the operational test plan were to provide the necessary operational data to evaluate the effectiveness of the top feed vacuum filtration system; to compare the performance of the top feed vacuum filter with a conventional bottom feed vacuum filter; and to determine the basic design and operating characteristics of the top feed vacuum filtration system.

The investigations were conducted on a 24-hour per day and seven day per week basis. This continuous operation mode was selected in order to investigate the impact of changes in sludge filtration characteristics which may occur diurnally, weekly, or seasonally. The data collection and evaluation was conducted during two periods: June 26, 1979 to September 24, 1979 and February 18, 1980 to August 7, 1980.

The operational test plan was divided into four operation modes which are listed below:

1. Equivalent pickup time and cycle time on experimental filters.
2. Equivalent solids loading on experimental filters.
3. Constant solids loading on experimental filters.
4. Optimization of sludge conditioning pH and comparison of filtering characteristics of MMSD conditioned sludge and locally conditioned sludge.

These four operational modes were designed to provide a maximum amount of data on which to compare the performance of the top feed and bottom feed vacuum filter. A description of each operational mode is presented below:

1. Equivalent pickup time and cycle time on experimental filters.

This operational mode evaluated the relative efficiency of filter cake formation. The top feed and bottom feed filters were operated at equivalent cycle times and pickup times and the resulting solids yields were analyzed to determine if there was a statistical difference between each experimental filter. Given the results of this analysis, the impact of the filter solids yield on filter cake solids was then determined and an overall performance evaluation of the top feed and bottom feed filter was developed.

2. Equivalent solids loading on experimental filters.

This operational mode determined if there was any statistically significant difference in the solids dewatering capacity of the top feed and bottom feed vacuum filter. Both experimental filters were operated at an equivalent solids loading rate and consequently both filters had equivalent solids yield (assuming the solids capture was the same for each filter). The cycle times on both filters were equivalent, but the pickup time may not have been equivalent. The pickup time for the bottom feed filter was used as a reference point. The top feed filter solids loading was then set to match the solids loading rate on the bottom feed filter. Throughout the study period the solids loading on the top feed filter was adjusted to equal the solids loading for the reference pickup time in the bottom feed filter.

3. Constant solids loading on experimental filters.

The difference between operation mode 3 and operation mode 2, was that mode 3 used a constant solids loading while mode 2 used an equivalent solids loading. In operation mode 2 the solids loading may vary with time, but it is equivalent for each filter. In operation mode 3 the solids loading is constant with time and also equivalent for each filter. Normally the solids loading rate will decrease with time at a given form time. In mode 3 the solids loading rate is held constant and the impact of this on other response and operating variables is then measured.

Current operating procedures at the Jones Island treatment plant recommend that the vacuum filters be water washed every 100 operating hours to regenerate filters whose performance has declined due to cloth blinding. This operation mode provided data on the rate of decrease of each experimental filter's performance over time when operated at a constant solids loading rate.

Parameters that were evaluated to determine the decrease in experimental filter performance during each study period were filter cake solids, pick-up time, filter cloth blinding, solids recovery, and filter quality.

4. Optimization of sludge conditioning pH and comparison of filtering characteristics of MMSD conditioned sludge and locally conditioned sludge.

Two aspects of sludge conditioning were investigated in this operational mode. The first aspect was the sludge pH required for optimum filtration. The second was the point of ferric chloride conditioning relative to the vacuum filter. Both aspects were found by the pilot study to be critical to the performance of the filter and the cost of operation.

The effectiveness of chemical conditioning is greatly influenced by sludge pH. Optimum flocculation conditions for waste activated sludge at Jones Island varies widely in terms of pounds of ferric chloride per ton dry solids, but is usually limited to a narrow range of values in terms of conditioned sludge pH. By varying the conditioned sludge pH and using operation modes 1 and 2, the optimum conditioning required by the top feed and bottom feed vacuum filters can be determined.

Currently sludge is conditioned at a central site at Jones Island (Acid House) and is distributed through several hundred feet of pipe to the filters. During this time the floc particles are subject to shear forces which may disrupt the floc particle, and reduce filtration efficiency. The experimental filters are equipped with individual floc units (sludge conditioned in individual floc units will hereafter be referred to as locally conditioned sludge) which discharge flocculated sludge through ten to twenty feet of pipe. The floc particles formed during conditioning will be retained along with filtration efficiency.

By comparing the response variables from the experimental filter with those of a similar production filter operated by Jones Island, the effect of adjacent flocculators and central flocculators on filtration efficiency was determined. The cake samples were removed from the Jones Island production filter before blow-off was applied to eliminate the adverse impact of discharged filtrate on cake solids.

Table 1 presents the beginning and ending dates for all the study periods in 1979 and 1980. Included is a listing of the operation modes used to evaluate the top feed vacuum filtration system.

SAMPLING PROCEDURES AND SAMPLE ANALYSIS

Throughout the evaluation of the top feed vacuum filtration system composite samples of feed sludge, filtrate, and filter cakes were collected. These samples were transported daily to the Environmental Research Center Laboratory for analysis. Associated with these samples were data that represented the operating parameters at the time of sampling. A description of these sampling procedures and sampling analysis is presented below.

During the operation of the top feed and bottom feed vacuum filters, samples of feed sludge and filtrate were composited every two hours. Forty milliliter samples of filtrate from the top feed filter and the bottom feed filter were composited for a total daily composite of 480 milliliters for each filter. Forty milliliter samples of feed sludge to the top feed filter or bottom feed filter were also composited for a total daily composite of 480 milliliter. Filtrate samples were collected from the downstream side of the filtrate pumps through a tap in the filtrate pipe. Feed sludge samples were collected from the sludge feed line at the point where it empties into the sludge vat or hopper. Filtrate samples were analyzed for suspended solids and iron, while feed sludge samples were analyzed for

TABLE 1. STUDY PERIODS FOR THE EVALUATION OF THE
TOP FEED VACUUM FILTRATION SYSTEM

Season	Study period		Operational mode
	Beginning date	Ending date	
Summer	6/21/79	7/3/79	2
	7/13/79	7/16/79	2
	7/18/79	8/3/79	2
	8/4/79	8/15/79	2
	8/15/79	8/25/79	1
	8/25/79	9/9/79	2
	9/9/79	9/20/79	2
Fall	9/20/79	9/24/79	2
Winter	2/19/80	2/22/80	2
	2/22/80	2/26/80	2
	2/27/80	3/1/80	2
	3/1/80	3/6/80	3
	3/8/80	3/11/80	3
	3/12/80	3/17/80	3
Spring	3/18/80	3/27/80	3
	3/28/80 ¹	4/3/80	2, 4
	4/3/80 ¹	4/7/80	2, 4
	4/7/80 ²	4/11/80	2, 4
	4/12/80 ²	4/17/80	2, 4
	4/17/80	4/20/80	2, 4
	4/21/80	4/28/80	2, 4
	5/1/80	5/3/80	2, 4
	5/9/80	5/19/80	2
	5/20/80 ³	5/27/80	2, 4
	5/29/80	6/6/80	2, 4
	6/6/80	6/17/80	2
Summer	6/17/80	6/23/80	2, 4
	6/25/80	7/1/80	2, 4
	7/3/80	7/14/80	2, 4
	7/15/80	7/26/80	2, 4
	7/26/80	7/30/80	2, 4
	8/1/80	8/7/80	2, 4

¹Only the bottom feed filter was operated during these two periods. The performance was compared to an MMSD production filter.

²Only the top feed filter was operated during this period. The performance was compared to an MMSD production filter.

³From 5/20/80 to 5/23/80 conditioned sludge was being flocculated.

total solids. Analytical techniques described in Standard Methods (3) were used for both samples. A description of these analytical procedures is presented in Appendix A.

Filter cake samples were usually collected once during every eight hour shift. A sampling schedule was developed so that the hour of cake sample would be different for a given shift over a period of eight days. In this way cake samples would be spread out randomly over the entire day and not biased to any particular hour.

The filter cake sampling procedure consisted of collecting three 0.1 ft² (92.9 cm²) pieces of filter cake, one from each end of the filter and one from the middle. The filter cloth that covers the sixteen foot long drums is made up of three equally wide pieces. The filter cake sample would thus represent a composite of the filter cake from each section of cloth.

A device that resembles a circular cookie cutter was used to punch out pieces of filter cake. These pieces were then put into a pre-weighed aluminum "potato dish" and then reweighed immediately. The point of sampling from the filter drum was randomly chosen. All cake samples, however, were taken from areas of the filter cloth where no blinding was present. The purpose of the filter cake sample was to determine the cake solids of a properly functioning filter cloth not of blinded cloth. However, at the time of each cake sample an estimate of the total blinding on the filter was recorded.

Samples of ferric chloride used in conditioning the sludge were analyzed for iron content. Iron analysis through April 22, 1980 was performed by the Jones Island Treatment Plant Laboratory using the Zimmermann Reinhardt oxidation/reduction process. All samples after that date were analyzed by the ERC laboratory using a Beckman Atomic Absorption Spectrophotometer.

DATA ANALYSIS AND STORAGE

Pertinent data collected during the operation of the top feed and bottom feed vacuum filters were compiled on a Hewlett Packard 9845B Desktop Computer. All data was originally stored on cassettes but were later transferred to diskettes. The computer was programmed to handle all graphing functions, formatting, and data analysis. A detailed description of the statistical analyses procedures and all data calculation is presented in Appendix B.

SECTION 7

TOP FEED VACUUM FILTER AND BOTTOM FEED VACUUM FILTER PERFORMANCE EVALUATION

The top feed vacuum filter and bottom feed vacuum filter were operated on a 24-hour, seven day per week, side by side basis throughout the project evaluation period. Both experimental vacuum filters were identical in design, and the only difference was the sludge pickup mode.

The initial evaluation period extended from June 26, 1979 to September 24, 1979. Both filters were shut down in September until an extension for the project was approved. The evaluation was started again on February 19, 1980 and was completed on August 7, 1980. The total evaluation period extended over 8 months of the year. No data was obtained during the months of October, November, December and January due to time gaps between contractual authorizations.

A summary of data from the top feed and bottom feed vacuum filter is presented below in Table 2. The data is averaged over the 1979 operation period and the 1980 operation period. Table 2 is intended to present the reader with average values for many of the operational and response parameters monitored during this project. This table provides a reference point for which the reader may evaluate the significance of the data presented in this section. Figure 10 is a plot of filter cake solids for all paired observations from 6/26/79 to 9/24/79 and 2/19/80 to 8/7/80. Figure 10 shows clearly the variation in cake solids over the entire evaluation period. The variation in cake solids is the result of many operation parameters as shown in Figure 5. (It should be noted here that all figures use a solid line to represent top feed filter data and a dashed line for bottom feed filter data unless otherwise stated).

The evaluation of the top and bottom feed vacuum filters was divided into thirty-two study periods. During each of these study periods the experimental filters were operated according to one of four operation modes. See Section 6 for a complete discussion of each operation mode. A summary of the results from each of the study periods is presented in Table 3. The results presented in Table 3 represent average values of all paired observations from the top feed and bottom feed filters during each study period. However, conditioned sludge pH is presented as a range and not an average. From June 26, 1979 to September 24, 1979 and from February 19, 1980 to March 27, 1980, both experimental filters were operated using sludge conditioned in the Jones Island Acid House. Data collected during this time will be analyzed to determine the optimum operating conditions of the top feed vacuum filter as well as the relative

TABLE 2. SUMMARY OF DATA FROM TOP FEED VACUUM FILTER AND
BOTTOM FEED VACUUM FILTER FOR 1979 AND 1980

	Feed solids, mg/l		Filtrate suspended solids, mg/l		Pickup vacuum, in. Hg		Dry vacuum, in. Hg		Cake solids, %		Solids yield ¹ , lb/hr/ft ²		Solids yield ² , lb/hr/ft ²		Sludge conditioning, lb FeCl ₃ / ton dry solids		Solids recovery, %	
	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
1979 ³	18,630	18,630	156	91	20.1	19.5	19.6	18.3	15.18	14.8	1.22	1.27	1.36	1.31	163	163	99.5	99.5
1980 ⁴	17,430	17,420	143	81	19.2	18.3	19.3	17.9	15.7	15.7	1.51	1.51	1.63	1.50	125	131	99.3	99.6

¹Based on sludge flow to filters.

²Based on filter cake solids.

³June 26, 1979 to September 24, 1979.

⁴Top feed filter operation: February 19, 1980 to March 27, 1980; April 7, 1980 to August 7, 1980.

Bottom feed filter operation: February 19, 1980 to April 7, 1980; April 20, 1980 to August 7, 1980.

2.54 cm = 1 inch.

4.89 kg/hr/ft² = 1 lb/hr/ft².

0.5 kg/metric ton = 1 lb/ton.

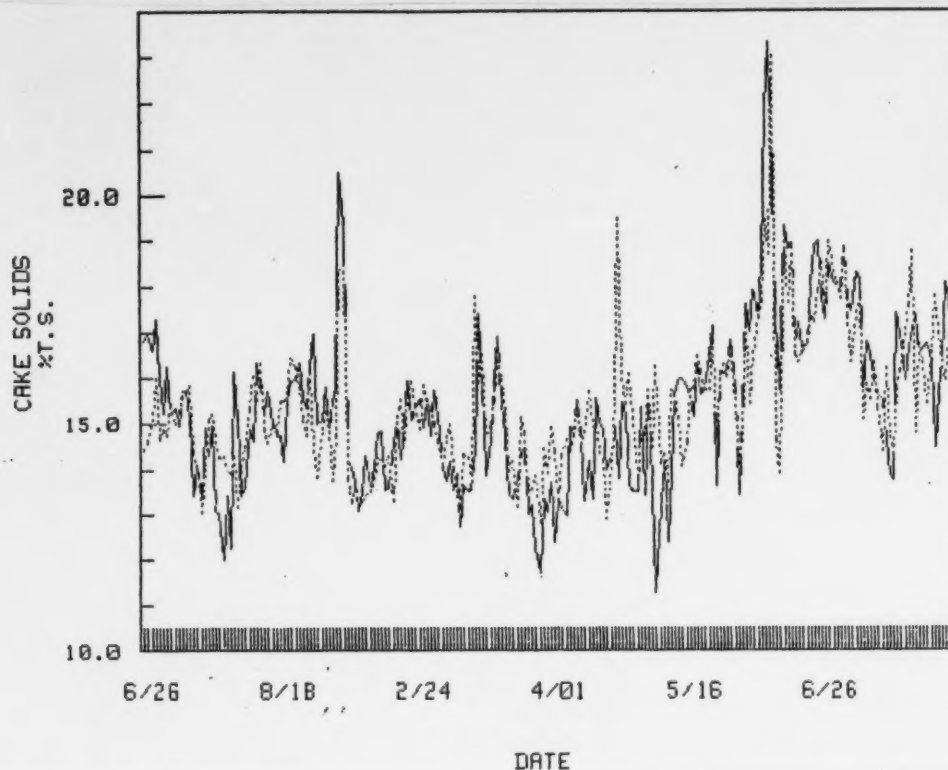


Figure 10. Top feed filter and bottom feed filter cake solids for the periods from 6/26/79 to 9/24/79 and 2/19/80 to 8/7/80. Each tick represents the average of all observations during each day. MMSD filter data is plotted from 3/28/80 to 4/20/80. See Table 3 for exact dates.

efficiency of cake formation and the impact of long term continuous operation on the top feed filter performance.

From March 28, 1980, until the end of the project on August 7, 1980, data collection centered around determining the impact of locally conditioned sludge pH on the top feed and bottom feed filter performance. During the time from March 2, 1980 to April 20, 1980 the top feed filter and bottom feed filter performance were being compared to production filters operated by MMSD. Technical problems with electronic pH controllers allowed the operation of only one filter at a time. It was during this time that an evaluation of the relative dewaterability of centrally conditioned sludge and locally conditioned sludge was made. During the periods of 5/9/80 to 5/19/80 the experimental filters were operated using MMSD conditioned sludge because of a failure in a chemical feed pump and from 6/6/80 to 6/17/80 the experimental filters were also operated using MMSD conditioned sludge because the blinding problem was excessive on both filters. Centrally conditioned sludge was used to determine if less blinding would occur.

The performance evaluation of the top feed filtration system will be presented in seven parts which are listed below:

1. Baseline data study period.
2. Impact of the top feed vacuum filter on filter cake formation.
3. Impact of the top feed vacuum filter on solids dewatering.
4. Optimization of conditioned sludge pH.
5. Impact of local sludge conditioning and central sludge conditioning on solids dewatering.
6. Long term continuous operation of top feed vacuum filter.
7. Maintenance requirements of the top feed filter and bottom feed filter.

BASELINE STUDY PERIOD

The purpose of this baseline study period was to establish the operating characteristics of the prototype top feed vacuum filter. Since this was the first time a full-scale top feed vacuum filter was operated it was felt the performance of the top feed filter should be compared to a conventional bottom feed filter operating at optimum sludge dewatering conditions. The Milwaukee Metropolitan Sewerage District (MMSD) utilizes a four minute cycle time and one minute pickup time to obtain time optimum levels of performance. During this study period the bottom feed experimental filter was set up to run at these conditions. The top feed filter was also operated at an equal cycle time and the sludge flow rate to the top feed filter was set to be approximately equal to the bottom feed filter. (The flow meters and sludge counters were not operational during this time so the exact flow to each experimental filter could not be determined).

Analysis of the cake solids from both filters from 6/26/79 to 7/3/79 indicated the top feed filter produced a significantly drier filter cake (16.47 percent vs. 15.05 percent), but the average solids yield for the top feed filter was less than the bottom feed filter (1.17 lb/hr/ft² vs. 1.36 lb/hr/ft²). The higher cake solids on the top feed filter is presumed to be the cause of the lower solids yield from the top feed filter. A plot of filter cake solids and solids yield is given in Figure 11.

The filters were shut down on July 3, 1979 for equipment repair with no paired observations being made until July 13, 1979. The baseline study period was continued on July 13, 1979 and was terminated on July 16, 1979. During this short period the feed flow was increased to the top feed filter to equal the bottom feed filter sludge loading. The resulting average yield from the top feed filter was 1.29 lb/hr/ft² while the bottom feed was 1.24 lb/hr/ft². The filter cake solids for the top feed filter was very similar to the bottom feed filter (15.40 percent vs. 15.44 percent) during this period. Figure 12 gives the filter yields and cake solids from July 13, 1979 to July 16, 1979.

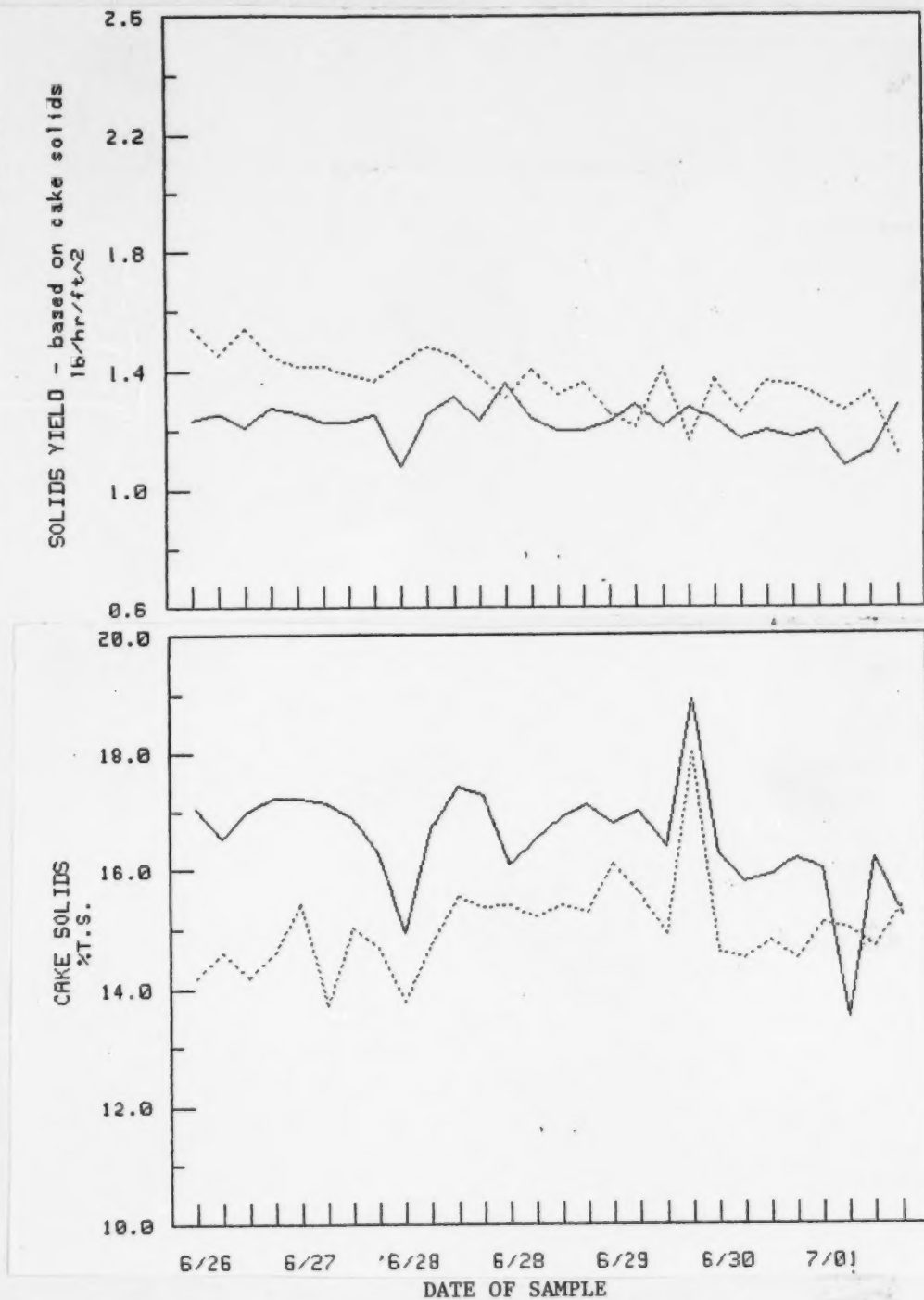


Figure 11. Plot of filter cake solids and filter yield for the period from 6/26/79 to 7/3/79. Each tick represents one paired observation. $4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$

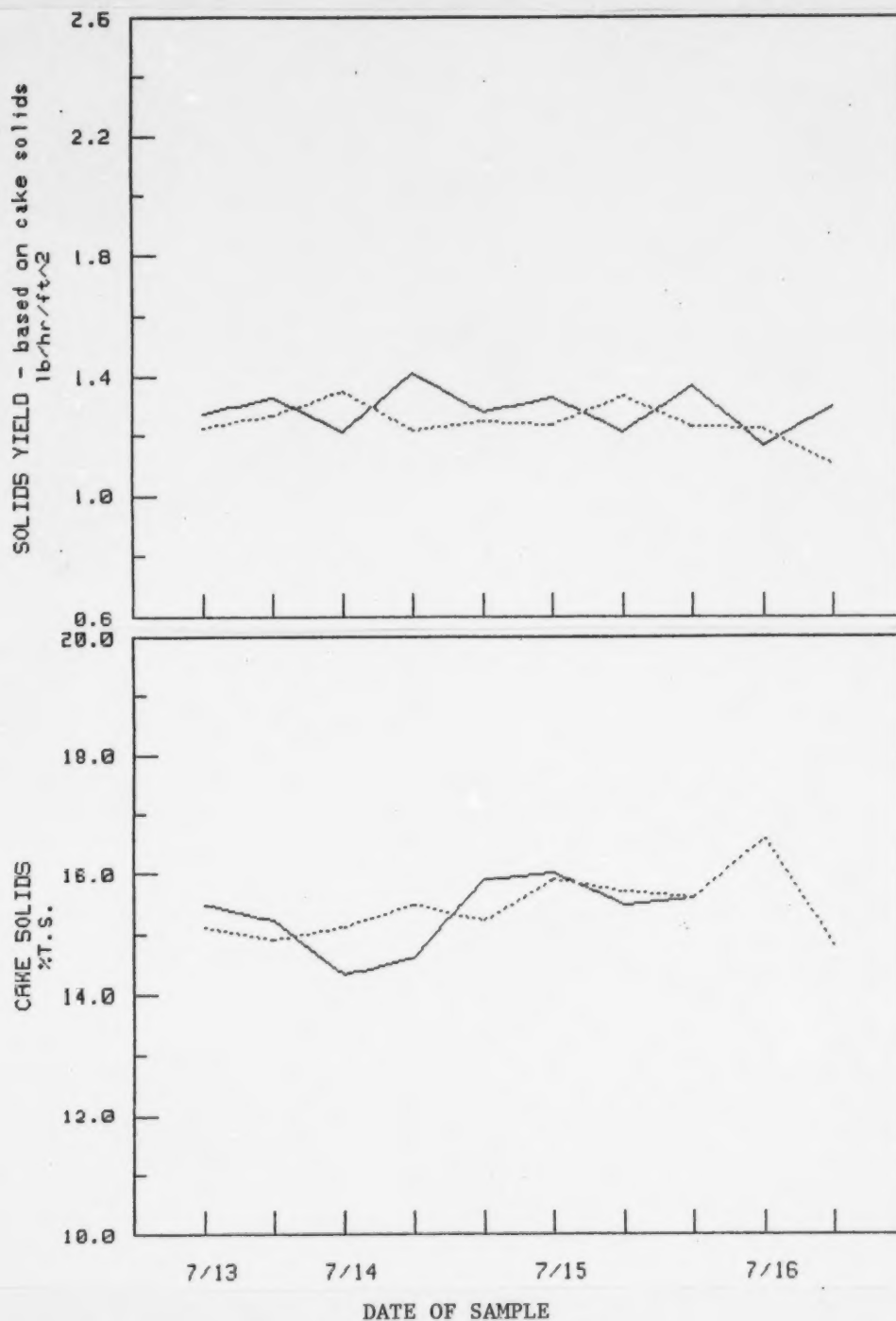


Figure 12. Plot of filter cake solids and filter yield for the period from 7/13/79 to 7/16/79. $4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$.

The relationship between filter cake solids and solids yield is presented in Figure 13. A linear regression analysis of the top feed filter data and bottom feed filter data shows that as the solids yield increases the cake solids decreases. This trend is expected because as the solids yield increases the thickness of the filter cake increases as well on the pickup time. With an increase in pickup time there is a decrease in drying time and as the cake thickness increases the headloss through the cake increases thus reducing the driving force available to remove water in the filter cake voids. Overall, less time and energy is available to dry the filter cake. It is important to note that the linear regression analysis shows the top feed filter producing a higher cake solids at a given solids yield than the bottom feed. The linear regression correlation for the top feed and bottom feed data was significant at a 95 percent confidence interval (*-top feed filter; +-bottom feed filter).

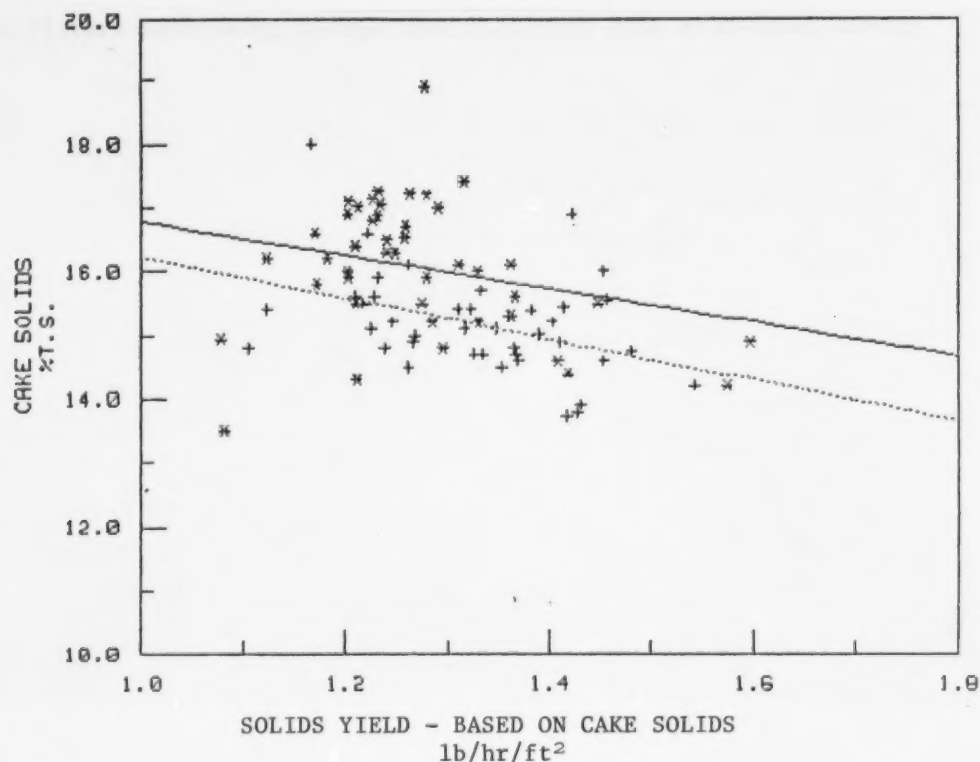


Figure 13. Relationship between cake solids and solids yield from 6/26/79 to 7/16/79. ($4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$).

For the period from 8/15/79 to 8/25/79, the top feed and bottom feed filters were operated at equivalent cycle times (4.0 minutes) and equivalent pickup times (an average of 42 seconds on the top feed filter and 40 seconds on the bottom feed filter). This was done to determine if the top feed filter produced a significantly larger solids yield than the bottom feed filter for a given

pickup time, and what impact this had on the filter cake solids. Figure 14 presents the pickup time, filter yield, and cake solids for the period from 8/15/79 to 8/25/79. The figure shows that for equivalent pickup times the top feed filter has a higher solids yield. The top feed filter during this period had an average solids yield of 1.29 lb dry solids/hr/ft² while the bottom feed filter had an average solids yield of 1.17 lb dry solids/hr/ft². A t-test on this data confirmed that the top feed filter solids yield was significantly higher than the bottom feed filter yield.

Given the significantly higher solids yield, the top graph of Figure 14 shows the top feed filter produced a filter cake that was as dry as the bottom feed filter. Filter cake solids varied widely for both experimental filters during the period shown. The average cake solids for the top feed filter during this period was 15.38 percent while the bottom feed filter had an average cake solids of 15.39 percent.

The pickup time for both filters varied throughout the study period as illustrated in the lower graph in Figure 14. Given this variation in pickup time the top feed filter still had a consistently higher solids yield than the bottom feed filter throughout the study period. The middle graph of Figure 14 plots the solids yield for both filters throughout the study period.

Throughout the entire evaluation period the top feed filter has consistently been more efficient at forming a sludge cake than the bottom feed filter. Figures 15, 16 and 17 are plots of pickup time and solids yield for the top feed and bottom feed filters. All the points on the graphs are paired observations from the top feed filter and bottom feed filter.

The period from 3/28/80 to 4/20/80 is not included because during this time only one experimental filter was operated at any given time.

The lower graph in each of the three figures is a plot of the bottom feed filter performance with each data point represented by a "+" symbol. The middle graph is a plot of the top feed filter performance and each data point is represented by an "*" symbol. (This symbol legend applies to all figures unless otherwise stated). The uppermost graph is a combination of the lower two.

Analysis of the bottom feed filter performance during the period from 6/26/79 to 9/24/79 (lower graph - Figure 15) shows the form times to be skewed toward the higher values while the top feed filter form times are skewed to the lower values. A combination of the top feed filter data and bottom feed filter data is presented in the uppermost graph in Figure 15. The lines plotted through each group of data points are the result of a linear regression analysis.

In each figure there is a significant correlation (95 percent confidence interval) between the pickup time and solids yield. (The line representing the top feed filter data is solid while the line representing the bottom feed filter data is broken). The linear regression analysis shows that for

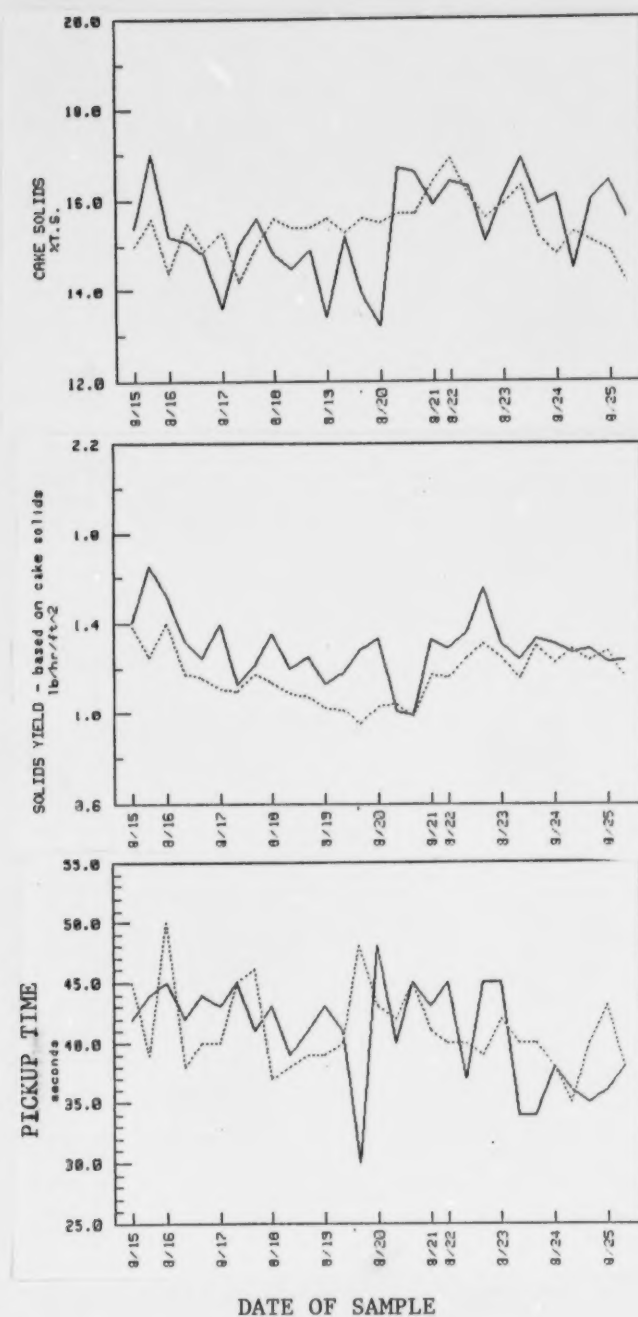


Figure 14. Plots of pickup time, solids yield, and cake solids during the period from 8/15/79 to 8/25/79. ($4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$).

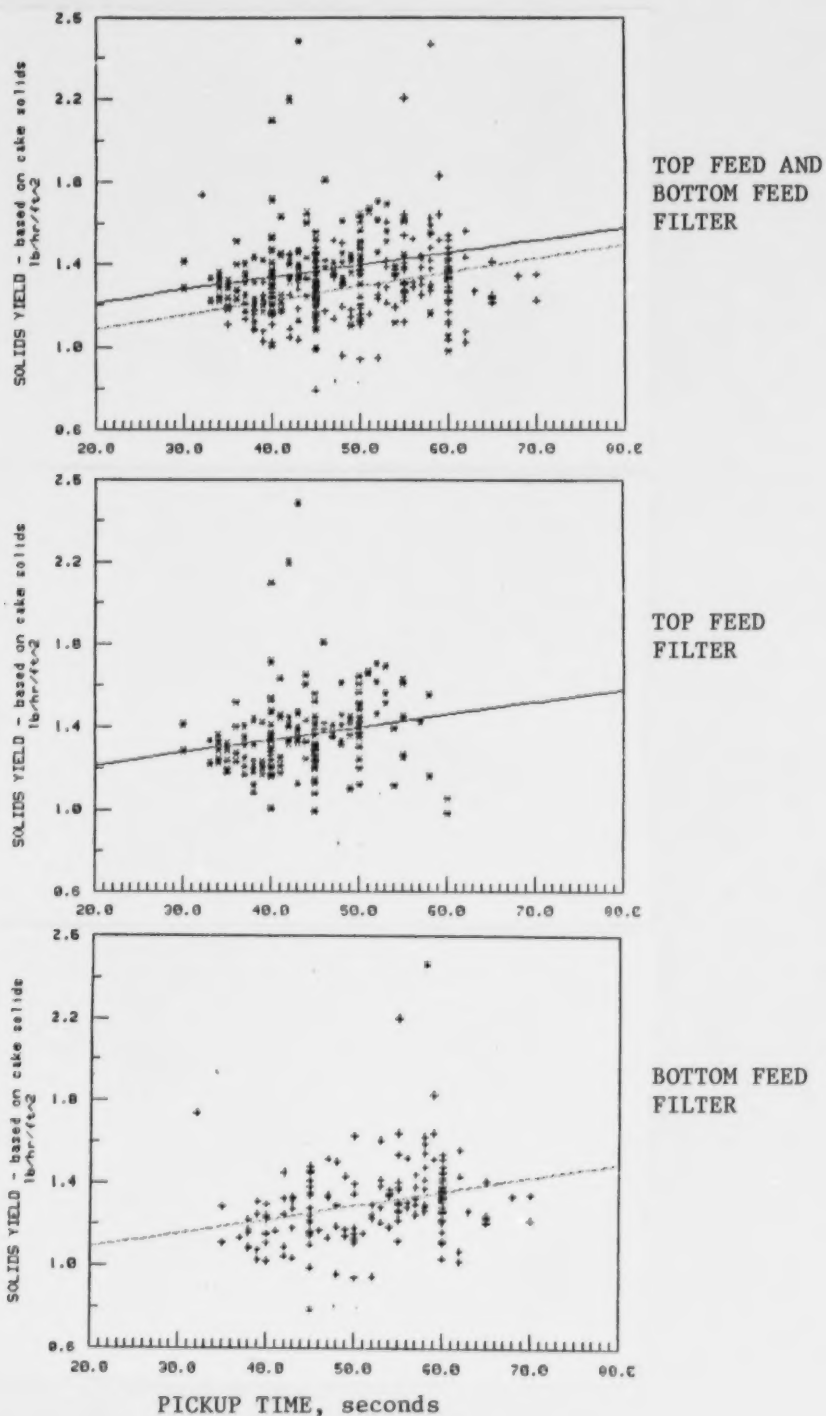


Figure 15. Plots of pickup time vs. solids yield from 6/26/79 to 9/24/79.
 (4.89 kg/hr/m² = 1 lb/hr/ft²).

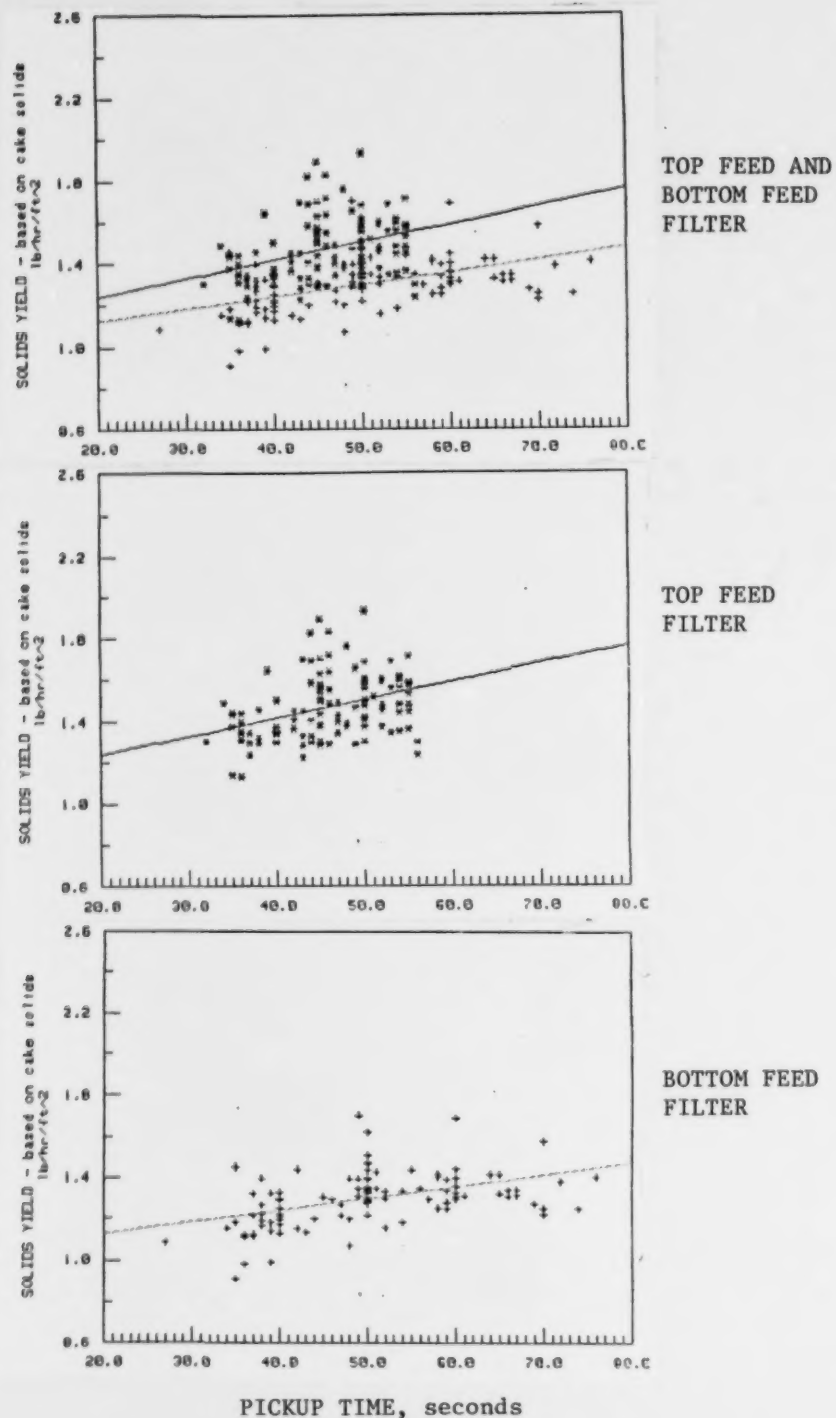


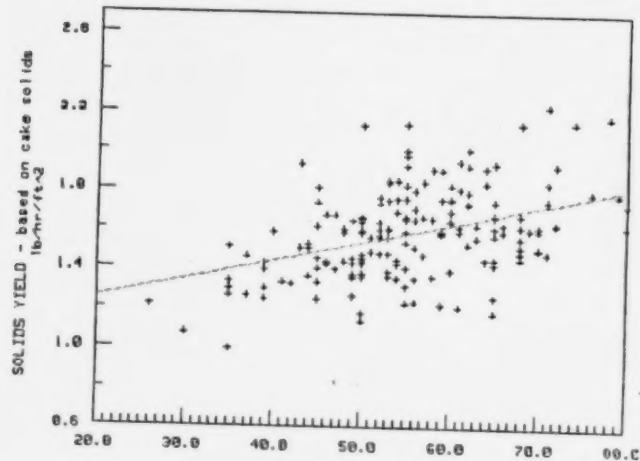
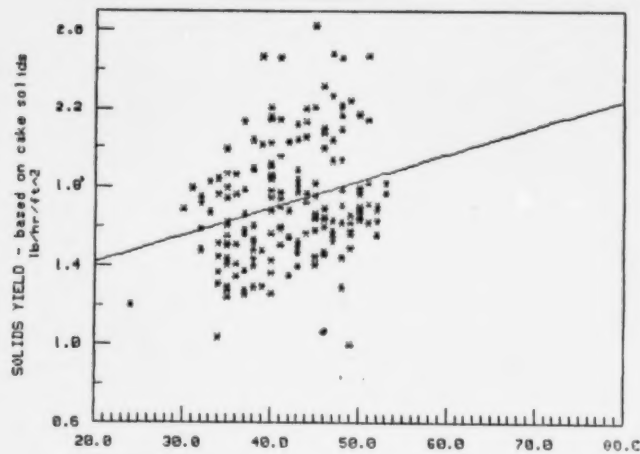
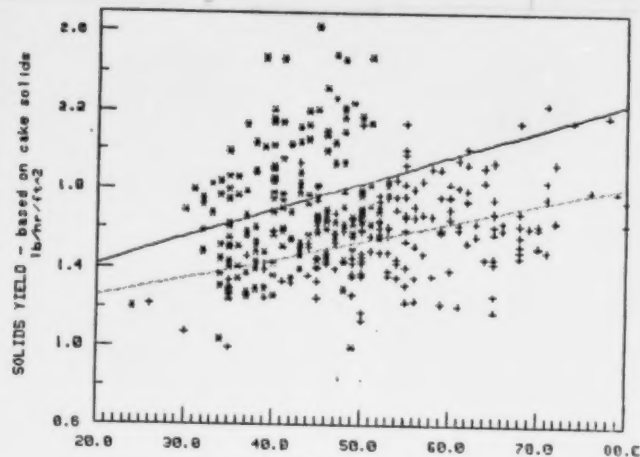
Figure 16. Plots of pickup time vs. solids yield for the period from 2/19/80 to 3/27/80. ($4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$).

BEGIN
FIRST
LINE OF
TEXT
HERE

CENTER OF
PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD,
BEGIN
SECTIONS
HERE



PICKUP TIME, seconds

Figure 17. Plots of pickup time vs. solids yield from 4/21/80 to 8/7/80.
Data is from local conditioning mode only and excludes data for
5/9/80 to 5/19/80 and from 6/6/80 to 6/17/80.
($4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$).

BEGIN
LAST LINE
OF TEST

BOTTOM LINE
AREA OF TEST

EPA Form 2250-6 (6-80)
PREVIOUSLY USE EPA FORM 2250

FACE NUMBER

TYPING GUIDE SHEET

a given form time the solids yield expected from the top feed filter will be greater than the bottom feed filter by approximately 0.1 lb/hr/ft². The average form time on the top feed filter was 40 seconds and the bottom feed filter was 51 seconds. The average solids yield on the top feed filter was 1.36 lb/hr/ft² while the bottom feed had an average of 1.31 lb/hr/ft². The top feed filter then had a 4 percent higher solids yield at a 22 percent lower pickup time.

Figure 16 plots form time against solids yield for the period from 2/19/80 to 3/27/80. During this period both filters were operated using MMSD conditioned sludge. A linear regression analysis of the top feed filter data and bottom feed filter data again showed the top feed filter produced a significantly higher solids yield than the bottom feed filter for this period. Based on the linear regression analysis the top feed filter will produce approximately 0.1 lb/hr/ft² greater than the bottom feed filter for a given form time. The average form time on the top feed filter was 46 seconds while the bottom feed filter average form time was 50 seconds. The average solids yield from the top feed filter was 1.47 lb/hr/ft² while the average solids yield from the bottom feed filter was 1.30 lb/hr/ft². The top feed filter then had a 13 percent greater yield at an 8 percent lower pickup time.

For the period from 4/21/80 to 8/7/80 both experimental filters were operated using locally conditioned sludge (except from 5/9/80 to 5/19/80 and 6/6/80 to 6/17/80 - both experimental filters were operated on centrally conditioned sludge). Figure 17 plots form time against solids yield during this period for the top feed filter and bottom feed filter. Compared to the solids yields data presented in Figures 15 and 16, the solids yield from the experimental filters during this period were much higher for a given form time. Table 4 presents the average solids yield and form times for each period and it is quite evident that the yield expected from the top feed filter is greater than the yield from the bottom feed filter for the form times used.

TABLE 4. AVERAGE FORM TIMES AND SOLIDS YIELDS FROM THE TOP FEED AND BOTTOM FEED FILTER

	Average form time, seconds		Average solids yield, lb/hr/ft ²	
	TF	BF	TF	BF
6/26/79 - 9/24/79	40	51	1.36	1.31
2/19/80 - 3/27/80	46	50	1.47	1.30
4/21/80 - 8/7/80*	42	55	1.72	1.58

*Excluding the periods from 5/9/80 to 5/19/80 and 6/6/80 to 6/17/80. (4.89 kg/hr/m² = 1 lb/hr/ft²).

A linear regression and analysis of the data presented in Figure 17 shows again that the top feed filter will produce a higher solids yield than the

bottom feed filter. At a form time of 50 seconds the linear regression indicates the top feed filter should produce a solids yield of 0.2 lb/hr/ft² greater than the bottom feed filter.

The data presented in Table 4 as well as the results of the linear regression analyses in Figures 15 to 17 show clearly that the top feed filter is more efficient at producing a filter cake than the bottom feed filter. As a result of this, the top feed filter has a longer dry time available for dewatering the filter cake. An analysis of the impact of the top feed vacuum filters on solids dewatering is presented in the next part.

IMPACT OF THE TOP FEED VACUUM FILTER ON SOLIDS DEWATERING

Operation mode 2 was designed to determine the relative impact of the top feed vacuum filter on filter cake dewatering. The top feed and bottom feed filter are operated at equivalent solids loading rates as determined by sludge flow. The resulting filter cakes are analyzed to determine which experimental filter is more effective at removing filtrate from the filter cake. The study periods covered the summer, winter and spring seasons. Table 5 gives a list of those study periods where the experimental filters were operated according to operation mode 2. (Other study periods in 1980 used operation mode 2, however, the impact of sludge pH was also being studied during these times and the results from these study periods will be discussed later in this section).

TABLE 5. STUDY PERIODS USING OPERATION MODE 2
TO EVALUATE TOP FEED FILTER PERFORMANCE

Study period	Study period
7/18/79 - 8/3/79	2/19/80 - 2/22/80
8/4/79 - 8/15/79	2/22/80 - 2/26/80
8/25/79 - 9/9/79	2/27/80 - 3/1/80
9/9/79 - 9/20/79	5/9/80 - 5/19/80
9/20/79 - 9/24/79	6/6/80 - 6/17/80

During all of these study periods the sludge being treated by the top feed filter and bottom feed filter was conditioned in the Jones Island Acid House. Figures 18 and 19 show the level of sludge conditioning for the waste activated sludge for all the study periods discussed in this part. Both experimental filters were treating the same conditioned sludge. It is assumed that Jones Island was conditioning that sludge to an optimum pH during these periods. By comparing the ferric chloride dose levels during these periods (1b FeCl₃/ton dry solids) it becomes evident how seasonal variations in sludge characteristics affect sludge conditioning. The excessive FeCl₃ required for conditioning in the fall reflects the

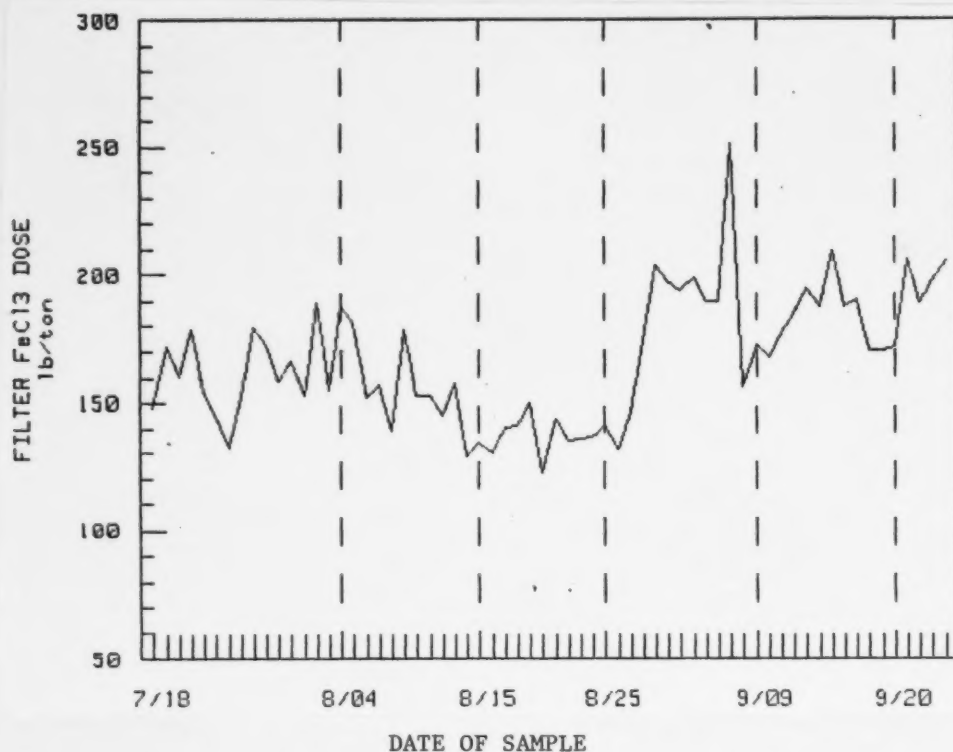


Figure 18. Sludge conditioning data for the top feed filter and bottom feed filter for the study periods beginning on the dates shown above. Each tick represents one day (0.5 kg/metric ton = 1 lb/ton).

high bicarbonate alkalinity level and the high level of organic constituents (5). The effect of seasonal variations of sludge characteristics will be discussed in detail later in this section.

In the dry zone of the vacuum filtration cycle the top feed vacuum filter has only one significant advantage over the bottom feed vacuum filter and that is a longer drying time. There are two reasons for the longer drying time. The first reason is the design of the top feed filter has the cake discharge much closer to the pickup zone, thus the length of the dry zone is increased. The second reason is the top feed filter is more efficient at picking up filter cake, thus shortening the pickup time.

The total dry time gained by the top feed filter will vary with how much more efficient the sludge pickup is. It is estimated the top feed filter gains 15 seconds of additional dry time based on design differences and 5 to 10 seconds based on more efficient sludge pickup. Thus 20 seconds to 25 seconds of additional dry time is available for the top feed filter. The impact of this additional dry time on the cake solids from the top feed filter was not significant, however, when operating at a four minute cycle time.

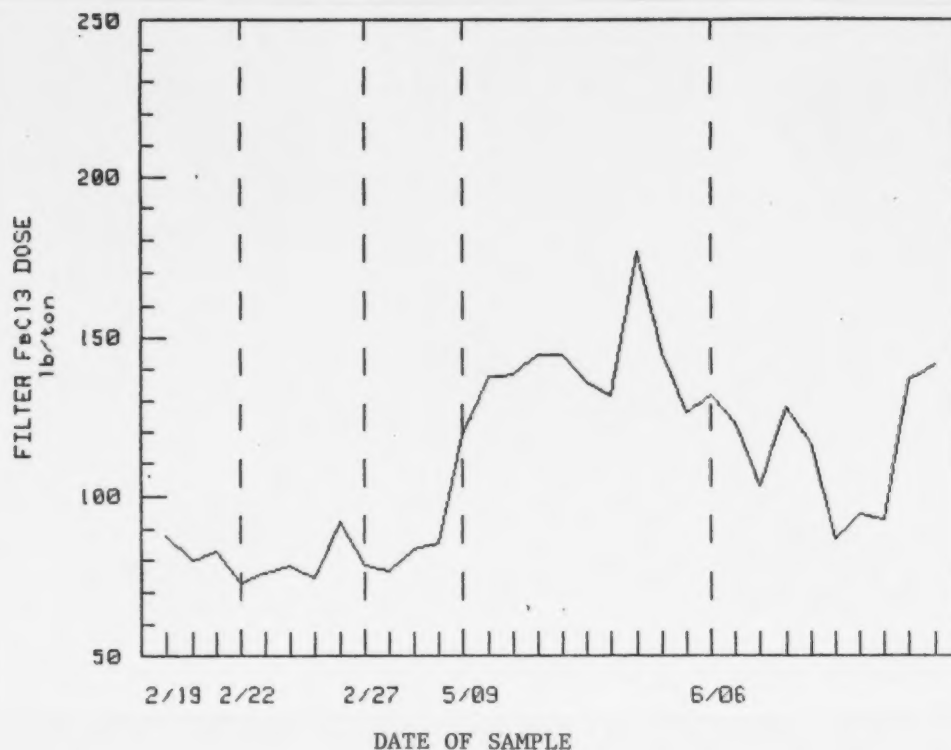


Figure 19. Sludge conditioning data for the top feed filter and bottom feed filter for the study periods beginning on the dates shown above. Each tick represents one day. (0.5 kg/metric ton = 1 lb/ton).

If the saturation level of the cake is reduced to the point where the only mechanism for removal of filtrate is through evaporation, the impact of 20 seconds to 25 seconds of extra dry time would be minimal and the top feed filter may thus be oversized. That is, for equivalent cake solids and filter yields the top feed drum could be sized smaller to eliminate excess area.

Table 6 presents a summary of the results from the study periods where the experimental filters were studied using operation mode 2. What should be noted from this data is the fact that the top feed filter produced significantly drier cake solids than the bottom feed filter during two of the three study periods where the cycle time was reduced to three minutes and forty seconds. In the third study period the top feed filter cake solids were greater than the bottom feed, but the difference was not statistically significant. The top feed filter produced higher cake solids in four of the seven study periods where the cycle time was four minutes. However, a statistically significant difference was not obtained in any of these study periods. In one study period (7/18/79 to 8/3/79) the bottom feed filter cake solids were significantly greater than the top feed filter cake solids.

TABLE 6. SUMMARY OF OPERATION DATA FROM EXPERIMENTAL FILTERS FUNCTIONING ACCORDING TO OPERATION MODE 2.

	Cycle time, min.		Pickup time, sec.		Cake solids, %		Results of T-test analysis on cake solids	Solids yield ¹ , lb/hr/ft ²	
	TF	BF	TF	BF	TF	BF		TF	BF
1979									
7/18 - 8/3/79	4.0	4.0	36	49	13.81	14.53	BF significantly drier than TF	1.08	1.11
8/4 - 8/15	4.0	4.0	53	59	14.76	14.74	BF not different from TF	1.48	1.40
8/25 - 9/9	3.67	3.67	35	41	15.5	14.7	TF significantly drier than BF	1.29	1.30
8/9 - 9/20	3.67	3.67	42	54	15.01	14.4	TF significantly drier than BF	1.44	1.42
9/20 - 9/24	3.67	3.67	37	45	14.28	14.14	TF not different from BF	1.27	1.29
1980									
2/19 - 2/22/80	4.0	4.0	46	59	15.02	15.15	TF not different from BF	1.38	1.35
2/22 - 2/26	4.0	4.0	45	50	15.49	15.64	TF not different from BF	1.61	1.38
2/27 - 3/1	4.0	4.0	37	40	15.26	14.97	TF not different from BF	1.39	1.24
5/9 - 5/18	4.0	4.0	46	60	15.07	15.02	TF not different from BF	1.61	1.52
6/6 - 6/17	4.0	4.0	34	56	19.13	18.08	TF not different from BF	1.42	1.61

¹Solids yield based on cake solids.
4.89 kg/hr/m² = 1 lb/hr/ft²

Graphs of solids yield based on sludge flow rate, solids yield based on cake solids, and cake solids for the operation mode 2 study periods in 1979 and 1980 are presented in Figure 20 and 21, respectively. The wide variation of solids yield and cake solids during these study periods are the result of several factors including sludge conditioning, filter blinding, and other sludge filtration characteristics. However, both experimental filters were operating with the same sludge so the variation in filtration characteristics has no impact on the performance evaluations.

Based on the results of the ten study periods discussed here the top feed filter does have a positive impact on solids dewatering. The high cake solids being discharged from the top feed filter may be attributed to the extra dry time available from the design of the top feed filter.

The top feed filter appears to function more efficiently at a shorter cycle time (3 minutes and 40 seconds) than the bottom feed filter. The additional dry time available to the top feed filter will allow the filter to be sized smaller than the bottom feed and still achieve equivalent cake solids and solids yields. Operation of the top feed filter at a three minute-forty second cycle time over a period of one month resulted in the top feed filter producing consistently drier cake solids than the bottom feed filter. The bottom feed filter required a longer cycle time of four minutes in order to produce equivalent cake solids as the top feed filter.

The top feed filter cake is formed more rapidly than the bottom feed filter cake and under a higher pressure difference. The impact of this rapid cake formation on the solids dewatering process appears to be minimal. Operation of both vacuum filters over a range of pickup vacuum levels from 16 inches (40.6 cm) Hg to 24 inches (61 cm) Hg showed no significant correlation between cake solids and vacuum level. Figures 22 and 23 present all the observations from the top feed filter and bottom feed filter obtained during this evaluation. In both cases there is no statistically significant correlation between pickup vacuum and filter cake solids. The line in each figure is from a linear regression analysis. The quantity of filtrate remaining in the voids and capillaries within the filter cake appear to be dependent only on the volume of the void spaces themselves. The only effect of the higher pickup vacuum is to form a filter cake more quickly but it does not reduce the cake void space. Thus the quantity of filtrate that must be removed from the top feed filter cake is equivalent to the volume of filtrate to be removed from the bottom feed filter cake.

It appears then that within the cycle times, pickup vacuum levels, and conditioning levels investigated during the study periods discussed above, the most significant impact of the top feed filtration system on solids dewatering is the top feed filter will dewater a given quantity of sludge in a shorter time. The difference in dewatering time is not great enough to significantly reduce the moisture level in the filter cake at a four minute cycle time. However, at a 3-minute 40 second cycle time the top feed filter will produce a consistently drier filter cake than the bottom feed filter.

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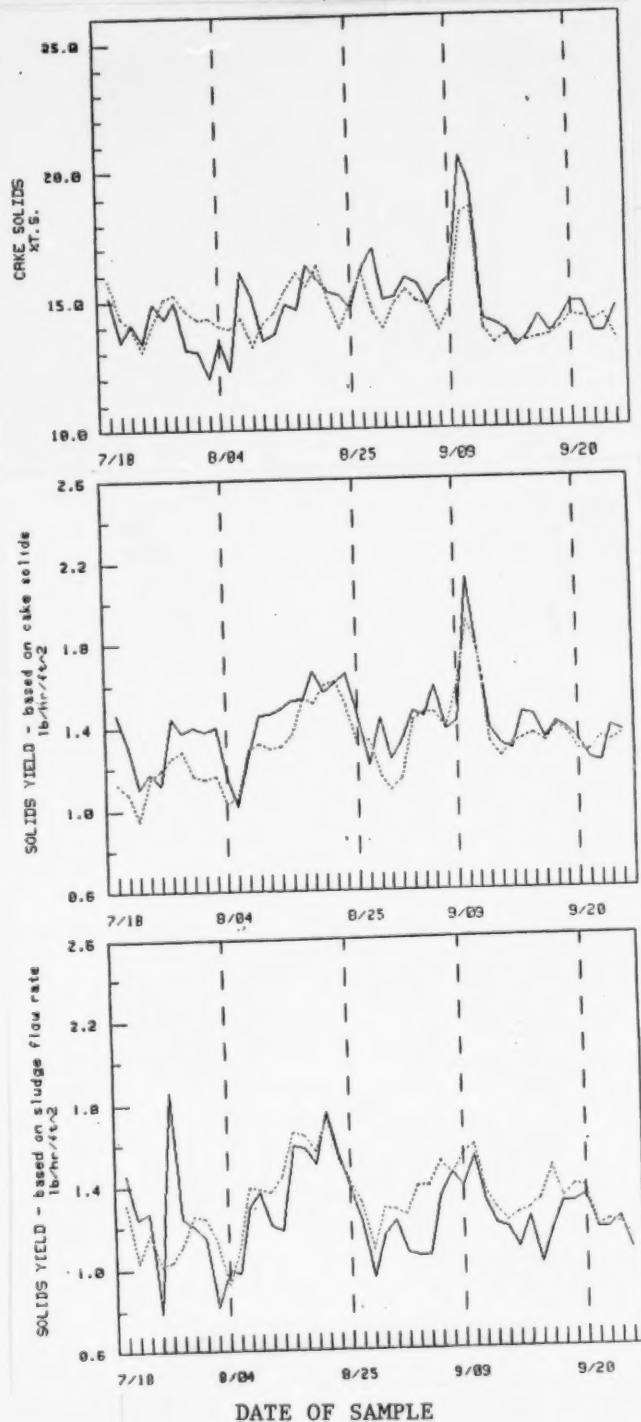


Figure 20. Plots of cake solids, solids yield based on sludge flow, and solids yield based on filter cake solids for the study periods beginning on the dates shown above. Each tick represents the average of all paired observations for one day ($4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$).

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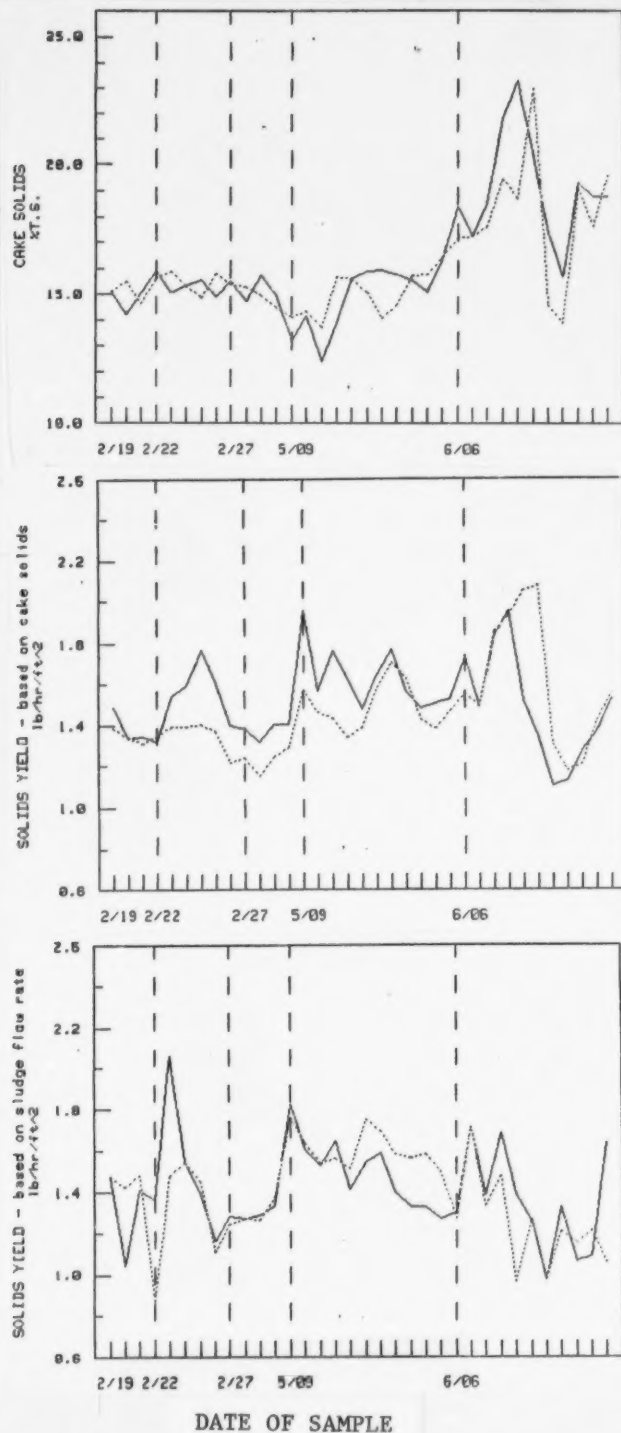


Figure 21. Plots of cake solids, solids yield based on sludge flow, and solids yield based on cake solids for the study periods beginning on the dates shown above. Each tick represents the average of all the paired observations for one day ($4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$).

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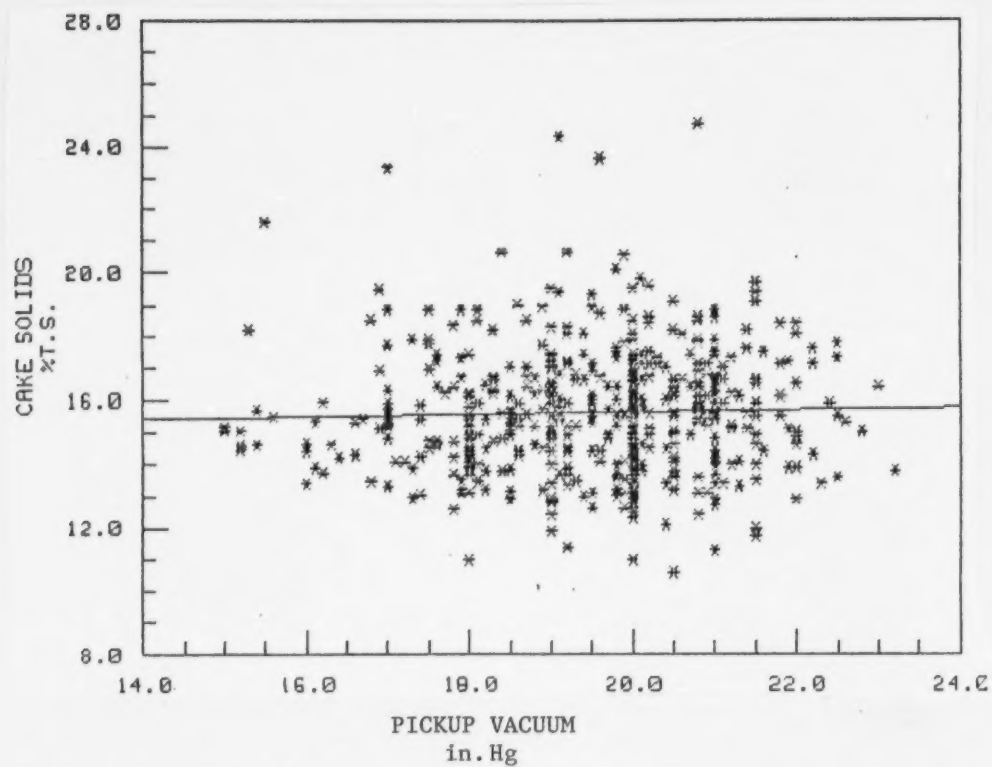


Figure 22. Plot of bottom feed filter pickup vacuum and cake solids for the periods from 6/26/79 to 8/7/80, excluding 3/28/80 to 4/20/80 (2.54 cm = 1 inch).

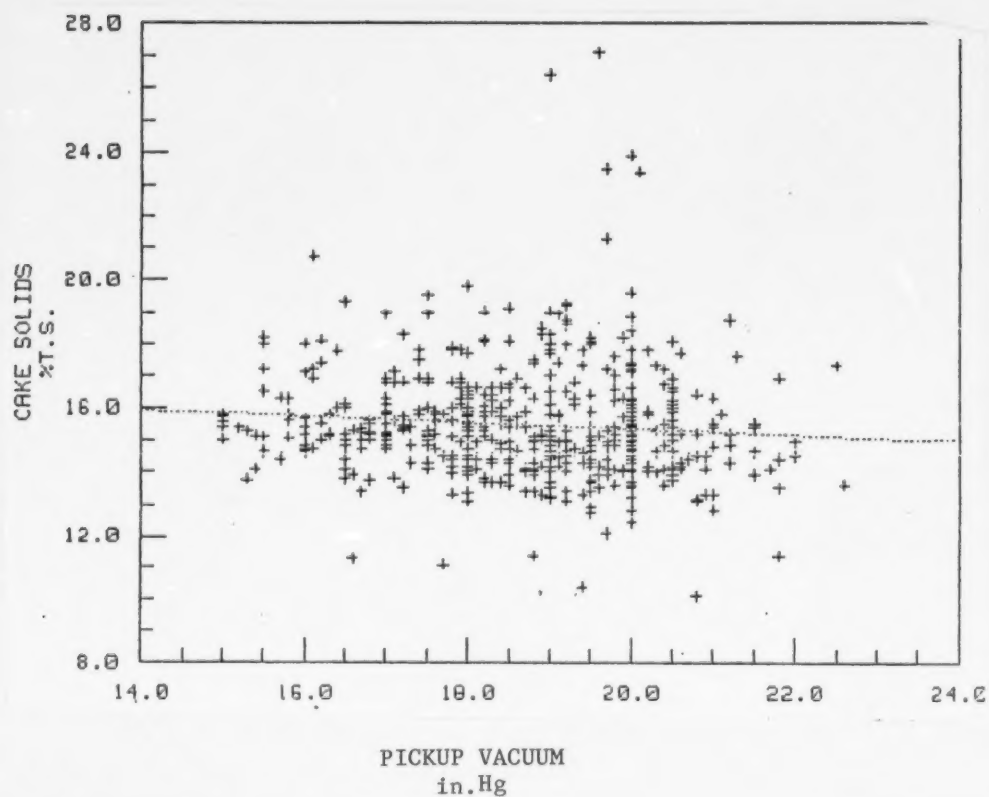


Figure 23. Plot of top feed filter pickup vacuum and cake solids for the period from 6/26/79 to 8/7/80 excluding 3/28/80 to 4/20/80 (2.54 cm = 1 inch).

OPTIMIZATION OF ACTIVATED SLUDGE CONDITIONING (pH) PRIOR TO VACUUM FILTRATION

The purpose of waste activated sludge conditioning with ferric chloride prior to vacuum filtration is to produce a floc particle that will form a rigid and porous structure that resists compression during sludge pickup and cake drying. The optimum dosage of ferric chloride will provide a rigid and porous filter cake that allows relatively easy movement of filtrate through its voids. Too much ferric chloride (low pH) produces a filter cake that cracks and as a result reduces the available vacuum. The vacuum will short circuit through these cracks instead of moving through the filter voids, and any residual filtrate in the filter cake will remain there. Too little ferric chloride (high pH) produces a filter cake that easily compresses and as a result the filter will blind.

The top feed and bottom feed filters were each equipped with flocculation tanks. Unconditioned sludge is distributed directly to each flocculator from the Acid House. Ferric chloride is then added at the inlet to the flocculator. Flocculation is achieved by air mixing. Probes to measure pH were positioned near the outlet of each basin.

The impact of a range of pH values from 3.2 to 4.2 were investigated during the project. The criteria for evaluating the performance of the experimental filters was described in operation mode 4 in Section 6. The list of study periods when the optimization of feed sludge pH was investigated is given in Table 7.

TABLE 7. STUDY PERIODS USING OPERATION MODE 4 TO EVALUATE THE PERFORMANCE OF THE TOP FEED FILTER

Study period	pH Set point		Observed pH range	
	TF	BF	TF	BF
4/21/80 - 4/28/80	3.5	3.5	3.4 - 4.0	3.0 - 3.8
5/1/80 - 5/3/80	3.2	3.2	3.2 - 4.0	3.2 - 3.3
5/20/80 - 5/27/80	3.5	3.2	3.1 - 3.8	3.0 - 3.7
5/29/80 - 6/6/80	3.2	3.5	3.0 - 3.6	3.1 - 3.4
6/17/80 - 6/23/80	3.8	3.5	3.4 - 4.0	3.0 - 4.0
6/25/80 - 7/2/80	3.5	3.8	3.2 - 3.6	3.6 - 4.1
7/2/80 - 7/14/80	3.5	3.5	2.9 - 3.7	3.2 - 4.0
7/15/80 - 7/26/80	3.8	3.8	3.1 - 3.9	3.4 - 4.4
7/26/80 - 7/30/80	4.0	4.0	3.6 - 4.0	3.7 - 4.1
8/1/80 - 8/7/80	4.2	4.2	3.7 - 4.2	3.5 - 4.2

Optimizing the sludge conditioning process involves determining the ideal mixing rate for floc particle formation; minimizing floc particle destruction when distributing the conditioned sludge to the vacuum filters; and determining the pH level (ferric chloride dose) that produces floc particles that dewater efficiently. The problem of floc shear associated with sludge distribution will be discussed in the next part, which compares the relative dewaterability of centrally conditioned sludge and locally conditioned sludge. The proper mixing rate for ideal flocculation was not addressed in this study. A rapid mixing rate was used in the flocculator at the point where the ferric chloride was introduced into the unconditioned sludge. This rapid mix ensured there would be sufficient particle contact for floc particle formation. After the rapid mix the sludge was mixed at a rate that prevented solids deposition in the flocculator. The residence time in the flocculator was between nine and eleven minutes depending on the flow rate. Rapid mix time was from ninety seconds to 120 seconds.

Determining the optimum sludge pH for the top feed filter and bottom feed filter involved operating the experimental filters at equivalent pH levels for each filter for six study periods and at different pH levels for each filter for the other four study periods. The results from these study periods are summarized in Table 8.

It should be noted that the optimum conditioning level for waste activated sludge will vary significantly over time. Table 3 shows that the level of ferric chloride will vary by a factor of 2.5 over a period of just four months. Variations in the optimum ferric chloride dose also occurs on a daily basis but only by as much as 25 percent. Figures 18 and 19 illustrate the variation from day to day for MMSD conditioned sludge. This variation in conditioning requirements made it difficult to optimize the performance of the experimental filters by comparing the results of one study period with the results from a different study period. The ferric chloride dose and optimum pH level may be entirely different for these two periods.

The strategy used here to optimize the performance of the two experimental filters involved comparing the filters performance within a given study period. Operating both filters at a given pH that may or may not be the optimum pH over a given period will provide data on the level of performance of each experimental filter. Of the ten study periods discussed here, six investigated the performance of the experimental filters when operated at equivalent pH levels and four investigated the performance of the experimental filters when each was operating at a different pH.

The results from the six study periods with both experimental filters functioning at equivalent pH levels indicate that neither filter has a particular advantage over the other in terms of ferric chloride conditioning requirements. Figure 24 shows the ferric chloride dosage rates for every day in the six study periods beginning on 4/21/80, 5/1/80, 7/2/80, 7/15/80, 7/26/80 and 8/1/80. Fluctuations in the ferric chloride dosage are due to changes in sludge characteristics. For the most part the experimental filters were using equivalent quantities of ferric chloride in each study period.

TABLE 8. SUMMARY OF RESULTS FROM TOP FEED FILTER
AND BOTTOM FEED FILTER FOR SLUDGE CONDITIONING
OPTIMIZATION STUDY PERIODS

Study period beginning:	Sludge conditioning, lb FeCl ₃ /ton dry solids				Filter cake solids, %		Filter yield ¹ , lb/hr/ft ²		Feed solids, mg/l	
	Set point pH		solids		TF	BF	TF	BF	TF	BF
	TF	BF	TF	BF						
4/21/80	3.5	3.5	136	138	14.28	15.32	1.58	1.60	14,590	14,590
5/1/80	3.2	3.2	152	172	13.50	15.20	1.73	1.70	15,980	15,980
5/20/80	3.5	3.2	102 (170) ²	125 (210)	15.75 (15.26)	15.82 (15.60)	1.63 (1.58)	1.68 (1.54)	19,860	19,860
5/29/80	3.2	3.5	202	216	16.33	15.65	1.79	1.37	25,840	25,840
6/17/80	3.8	3.5	165	198	17.45	16.83	1.54	1.29	17,380	17,380
6/25/80	3.5	3.8	152	147	18.11	18.78	1.90	1.97	19,080	19,080
7/2/80	3.5	3.5	159	169	17.13	16.51	1.68	1.71	17,320	17,320
7/15/80	3.8	3.8	130	140	15.64	16.04	1.38	1.55	18,870	18,870
7/26/80	4.0	4.0	119	128	16.91	15.86	1.47	1.69	19,760	19,760
8/1/80	4.2	4.2	149	151	16.13	16.43	1.39	16.43	14,900	14,900

¹Filter yield based on cake solids.

²Average values if data from 5/20 to 5/23 is disregarded.

0.5 kg/metric ton = 1 lb/ton

4.89 kg/hr/m² = 1 lb/hr/ft²

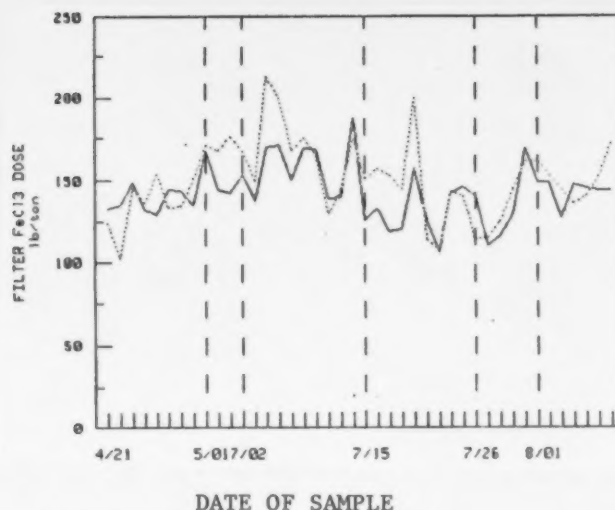


Figure 24. Ferric chloride dosage (lb ferric chloride/ton dry solids) for six study periods beginning on the dates shown above. Each tick mark represents one day. (0.5 kg/metric ton = 1 lb/ton).

Two study periods, one in the spring (4/21/80 to 4/28/80) and one in the summer (7/2/80 to 7/14/80), investigated the performance of the experimental filters at a pH of 3.5. Figure 25 presents the results for all the paired observations during these two study periods as well as the four other study periods investigating the performance of the experimental filters using equivalent ferric chloride dosages. During the study period beginning on 4/21/80, the bottom feed filter had significantly higher cake solids (15.32 percent vs. 14.28 percent) than the top feed filter at an equivalent solids yield (bottom feed - 1.6 lb/hr/ft²; top feed - 1.58 lb/hr/ft²) and at an equivalent ferric chloride dosage (bottom feed - 138 lb FeCl₃/ton d.s.; top feed - 136 lb FeCl₃/ton d.s.). This performance was not repeated by the bottom feed filter during the study period beginning on 7/2/80. During this study period the top feed filter had significantly higher solids (17.13 percent vs. 16.5 percent) than the bottom feed filter, yet both experimental filters were again operating at a pH of 3.5. The ferric chloride dosage was slightly less on the bottom feed filter (159 lb/ton d.s. vs. 169 lb/ton d.s.), but the yields from each experimental filter were equivalent (top feed - 1.68 lb/hr/ft²; bottom feed - 1.71 lb/hr/ft²). In both of the above study periods, the difference in cake solids from the two filters were statistically significant at a 95 percent confidence level.

None of the other four study periods investigating the performance of the experimental filters while they were operating at equivalent pH levels had statistically different results from the two experimental filters. The results of these study periods which started on 5/1, 7/15, 7/26, and 8/1 did indicate that the pH level required to produce easily

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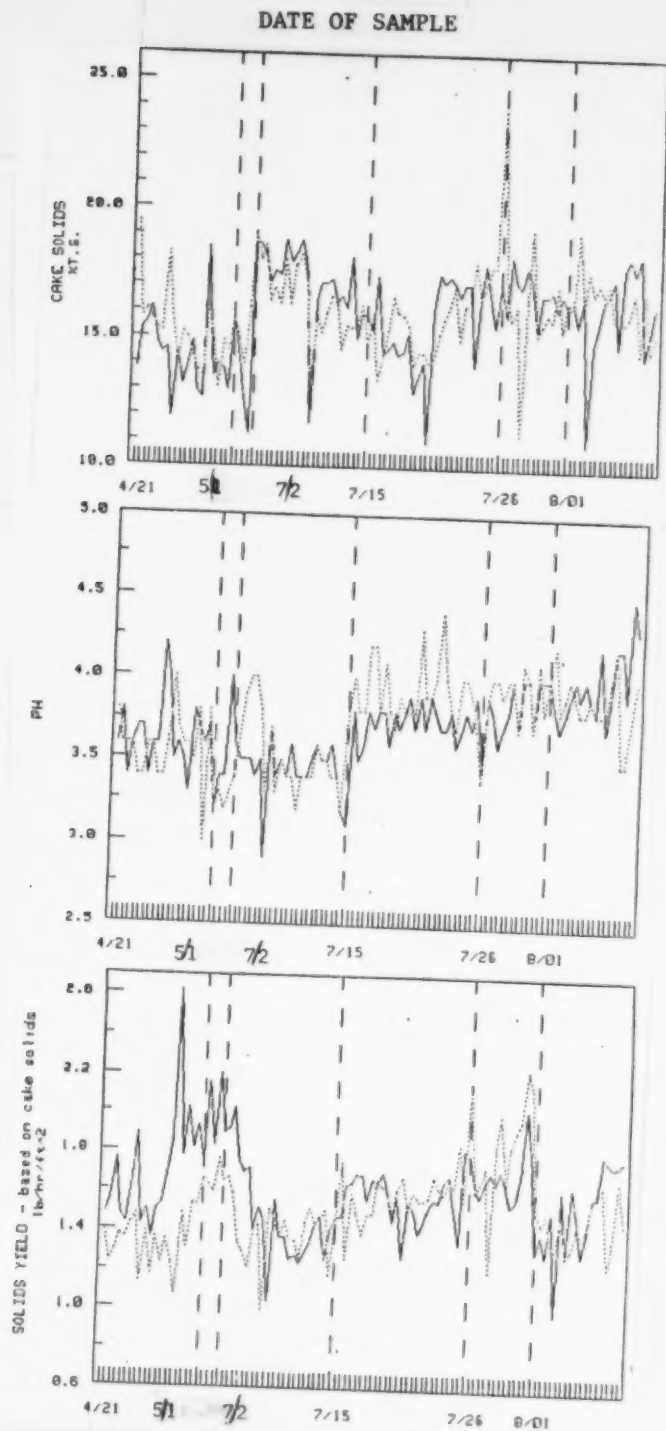


Figure 25. Plots of solids yield, pH and cake solids for the study periods beginning on the dates shown above. Tick marks between dates represent paired observations during that study period. ($4.89 \text{ kg/hr/m}^2 \approx 1 \text{ lb/hr/ft}^2$).

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dewaterable sludge could be raised to 4.0 to 4.2. Figure 24 shows the ferric chloride dosage for each study period. From 7/15 to 8/7 the pH was raised from 3.8 to 4.2 with no significant drop in cake solids on solids yield. The solids yield did drop initially when the filters were operating at a pH of 4.2, but increased at the end of the study period to a level equivalent to when the filters were operating at a pH of 3.8. (The bottom feed pH level in Figure 25 during the study period beginning on 7/15 shows several values above 4.0. These values are incorrect. The pH probe was not functioning properly and as a result the pH level would drift upward on the recorder. Figure 24 confirms that the actual pH level should be equivalent to the top feed filter).

During the study periods beginning on 5/20, 5/29, 6/17 and 6/25 the top feed and bottom feed filters were operated at different pH levels to determine the effect of different ferric chloride dosages on sludge dewaterability. One filter was operated at a higher ferric chloride dosage for two of the study periods and then the ferric chloride dosage was changed and the other filter was operated at a higher level. Figure 26 shows the ferric chloride dosages for all four of these study periods. (From 5/20 to 5/23 the conditioned sludge line was mistakenly opened instead of the unconditioned sludge line so conditioned sludge was being treated with ferric chloride. The values in Table 8 includes data from these four days. If these four days are disregarded the average values for ferric chloride dose are 170 lb/ton d.s. for the top feed filter, 210 lb/ton d.s. for the bottom feed filter; 1.58 lb/hr/ft² solids yield from the top feed filter, 1.54 lb/hr/ft² from the bottom feed filter; and 15.26 percent cake solids from the top feed filter and 15.60 percent cake solids from the bottom feed filter).

Figure 27 shows that for the above four study periods there is no consistent difference in performance between the top feed and bottom feed filters. The results from the study periods beginning on 5/20 and 5/29 appears to indicate that the filter operating at the lower pH will produce drier cake solids at an equivalent or higher solids yield. However, when the pH level is raised on both filters to 3.5 and 3.8 in the study periods beginning on 6/7 and 6/25 this trend does not appear. The top feed filter during the study period beginning on 6/17 had statistically higher cake solids (17.45 percent vs. 16.83 percent) than the bottom feed filter when operating at a higher pH than the bottom feed filter and also had statistically higher solids yield (1.54 lb/hr/ft² vs. 1.29 lb/hr/ft²). In the study period beginning on 6/25 the top feed filter operated at a lower pH and had lower cake solids than the bottom feed filter (18.11 percent vs. 18.18 percent) and also had a lower solids yield (1.90 lb/hr/ft² vs. 1.97 lb/hr/ft²).

These results indicate there may be a pH range of greater than 0.3 pH units over which a vacuum filter may be operated efficiently. The most desirable operating condition would be one that maintained a high solids yield and cake solids while using a minimum amount of ferric chloride. It may then be concluded from this data that operating at the high end of the optimum pH range would produce high yields and high cake solids. This data also indicates the top feed filter does

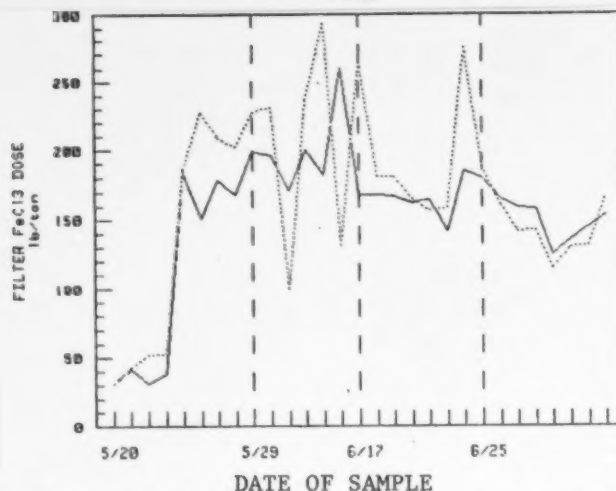


Figure 26. Ferric chloride dosages for four study periods beginning on the dates shown above. Each tick represents one day (0.5 kg/metric ton = 1 lb/ton).

require an equivalent amount of ferric chloride for sludge conditioning as the bottom feed filter and the only expected benefits from the top feed filter would be limited to those benefits discussed in the first three parts of this section.

As discussed earlier ferric chloride is required to form rigid and porous floc particles before the sludge is amenable to vacuum dewatering. Since the mode of sludge feed in no way affects the formation of floc particles there would be no particular advantage in terms of sludge conditioning from using a top feed filter. The bottom feed filter does use a agitator to keep the floc particles from settling in the sludge vat, but the impact of this on the integrity of the sludge particle appears to be minimal. The low level of turbulence developed by the agitator also appears not to interfere significantly with cake formation in the pick up zone.

Conditioned sludge pH during the study periods discussed above ranged from 2.8 to 4.4. These values are the lower and upper limits of pH and operating at or beyond these limits for extended periods of time may adversely affect the performance of the vacuum filters. Observations made during the study periods discussed above showed that significant blinding will occur within a few hours if operated beyond these limits. Efficient operation of vacuum filters can be obtained at a pH from 3.2 to 4.0, however, the best performance would probably occur between a pH of 3.5 to 3.8. Operating at a high pH will obviously reduce conditioning chemical costs, but these savings must be balanced against the filter performance.

The shear forces in the long pipelines leading from a central conditioning facility to the vacuum filters may have an adverse impact on the sludge particles. A comparison of the performance of a production filter using centrally conditioned sludge and a vacuum filter using locally conditioned sludge is presented in the next part.

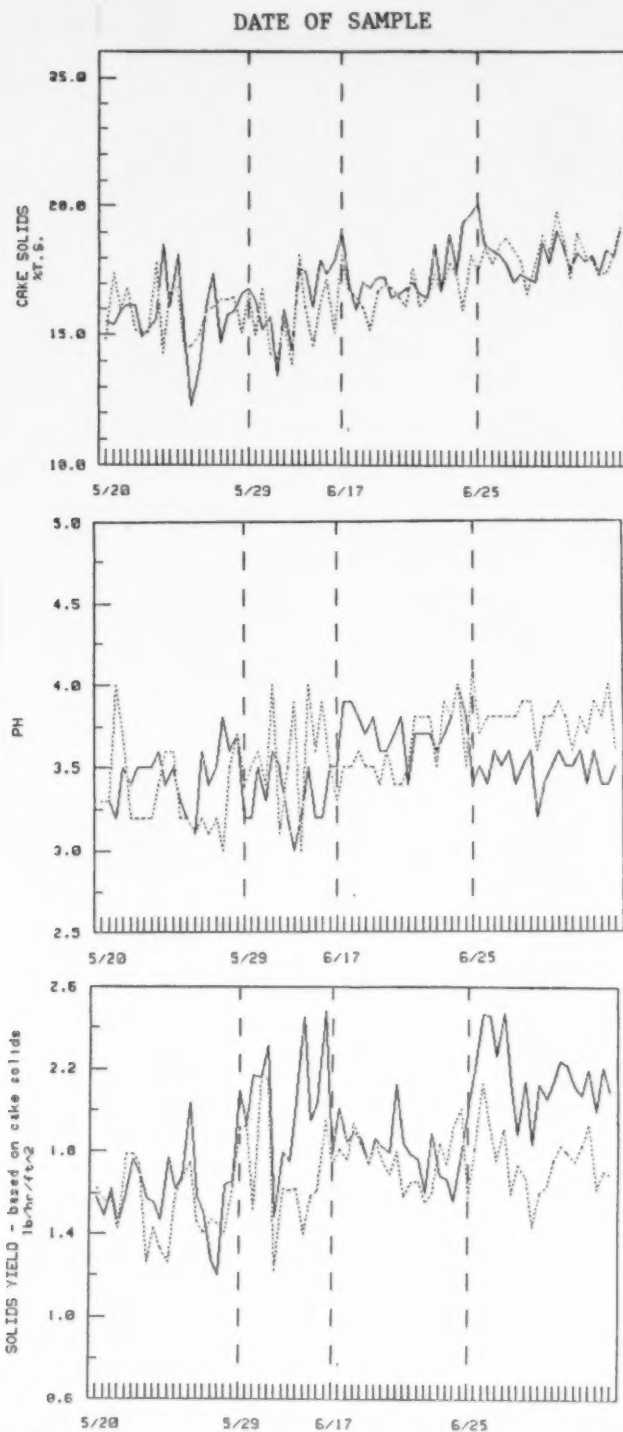


Figure 27. Plots of solids yield, pH and cake solids for the study periods beginning on the dates shown above. Tick marks between dates represent paired observations ($4.89 \text{ kg/hr/m}^2 = 1' \text{ lb/hr/ft}^2$).

IMPACT OF LOCAL SLUDGE CONDITIONING AND CENTRAL SLUDGE CONDITIONING ON SOLIDS DEWATERING

The major advantage from the use of local sludge conditioning (conditioning sludge in flocculators that are adjacent to the vacuum filter) is the elimination of shear forces that tend to disrupt the floc particle. These floc particles are essential for good sludge dewatering and they must be rigid enough to withstand compression under relatively high pressures. The greatest impact of shear forces on floc particles would probably not be a reduction in the rigidity of the particle, but rather a reduction in the porosity of the filter cake. If floc particles have been broken up by shear forces, then these smaller particles would fill the voids between the larger floc particles causing a reduction in the porosity of the filter cake and increasing the headloss across the filter cake. A higher headloss would increase the pickup time and increase the level of vacuum required to dry the filter cake.

The performance of the top feed filter and bottom feed filter using local sludge conditioning was compared to the performance of an MMSD production filter using central sludge conditioning. The bottom feed filter performance was compared to the production filter performance during the study periods beginning on 3/28/80 to 4/3/80 while the top feed filter performance was compared to the production filter performance on the study periods beginning on 4/7/80, 4/12/80 and 4/17/80. A summary of the results from the experimental filters and the production filter is presented in Table 9.

The results of the comparison between the bottom feed filter performance and the production filter performance show the experimental bottom feed filter consistently produced higher cake solids (13.79 percent vs. 12.59 percent) and higher solids yields (1.60 lb/hr/ft² vs. 1.39 lb/hr/ft²) when operated at a lower ferric chloride dosage than the production filters (145 lb ferric chloride/ton dry solids vs. 197 lb ferric chloride/ton dry solids). The bottom feed filter also produced higher cake solids (14.14 percent vs. 13.24 percent) and solids yield (1.65 lb/hr/ft² vs. 1.40 lb/hr/ft²) when operated at a higher ferric chloride dosage (114 lb ferric chloride/ton dry solids vs. 87 lb ferric chloride/ton dry solids) than the production filter. In both study periods the difference in cake solids and solids yield were statistically significant. A plot of the ferric chloride dosage for all the days in the study periods beginning on 3/28/80 and 4/3/80 is presented in Figure 28.

The variations in cake solids, solids yield, and sludge pH are presented in Figure 29. These figures show how the bottom feed filter performed consistently better than the production filter. All the points on the graphs represent paired observations.

A comparison between the top feed filter performance using locally conditioned sludge and a production filter using centrally conditioned sludge was made during the study periods beginning on 4/7, 4/12 and 4/17.

TABLE 9. SUMMARY OF RESULTS FROM TOP FEED FILTER, BOTTOM FEED FILTER,
AND MMSD PRODUCTION FILTER DURING COMPARISON OF LOCAL SLUDGE
CONDITIONING AND CENTRAL SLUDGE CONDITIONING.

	Set point, pH		Sludge conditioning, 1b FeCl ₃ /ton dry solids		Filter cake solids, %		Filter yield ¹ , lb/hr/ft ²		Feed solids, mg/l	
	MMSD	BF	MMSD	BF	MMSD	BF	MMSD	BF	MMSD	BF
3/28/80 - 4/3/80	3.4	3.5	197	145	12.59	13.79	1.39	1.60	17,020	17,020
4/3/80 - 4/7/80	3.3	3.8	87	114	13.24	14.14	1.40	1.65	17,580	17,580
	TF		TF		TF		TF		TF	
	MMSD	MMSD	MMSD	MMSD	MMSD	MMSD	MMSD	MMSD	MMSD	MMSD
4/7/80 - 4/11/80	3.8	3.5	82	85	14.72	14.82	1.69	1.59	18,660	18,660
4/12/80 - 4/17/80	3.8	3.4	114	92	14.59	14.71	1.92	1.67	17,100	17,100
4/17/80 - 4/20/80	3.5	3.4	124	115	14.16	13.93	1.97	1.47	15,980	15,980

0.5 kg/metric ton = 1 lb/ton
4.89 kg/hr/m² = 1 lb/hr/ft²

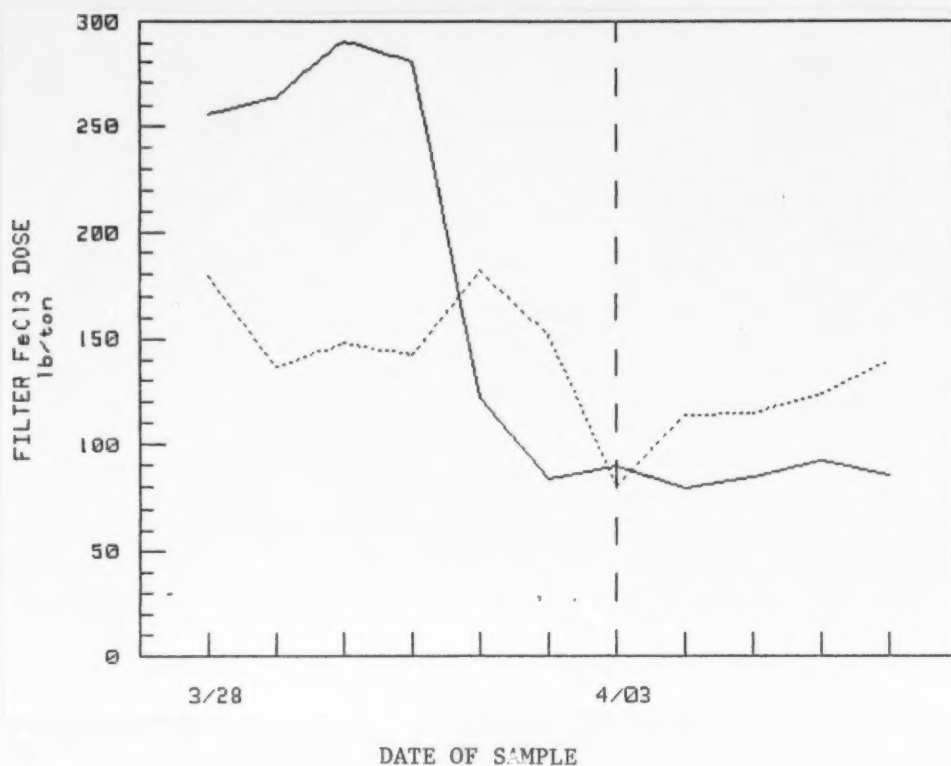


Figure 28. Plot of ferric chloride dosage for the study periods beginning on the dates shown above. Each tick represents one day. (—MMSD production filter; ---experimental bottom feed filter).
0.5 kg/metric ton = 1 lb/ton.

In all three periods the top feed filter had higher solids yield, but only had higher average cake solids in the period beginning on 4/17. The top feed filter was also treating sludge conditioned with a higher ferric chloride dosage. Figure 30 presents the daily ferric chloride dosage for the top feed and production filter.

There was no statistically significant difference between the cake solids data from the top feed filter and production filter during any of these study periods; however, the top feed filter did have solids yields that were statistically greater than the production filter solids yield. A plot of solids yield, sludge pH, and filter cake solids for all three of these study periods is presented in Figure 31. See Table 3 for the average values of these parameters.

The performance of the top feed and bottom feed filters when using locally conditioned sludge was for the most part better than the production filter performance. The statistically higher yields by the experimental filters in all five study periods and the statistically equivalent or higher cake solids from the production filters indicate clearly that local conditioning does provide an advantage over central conditioning.

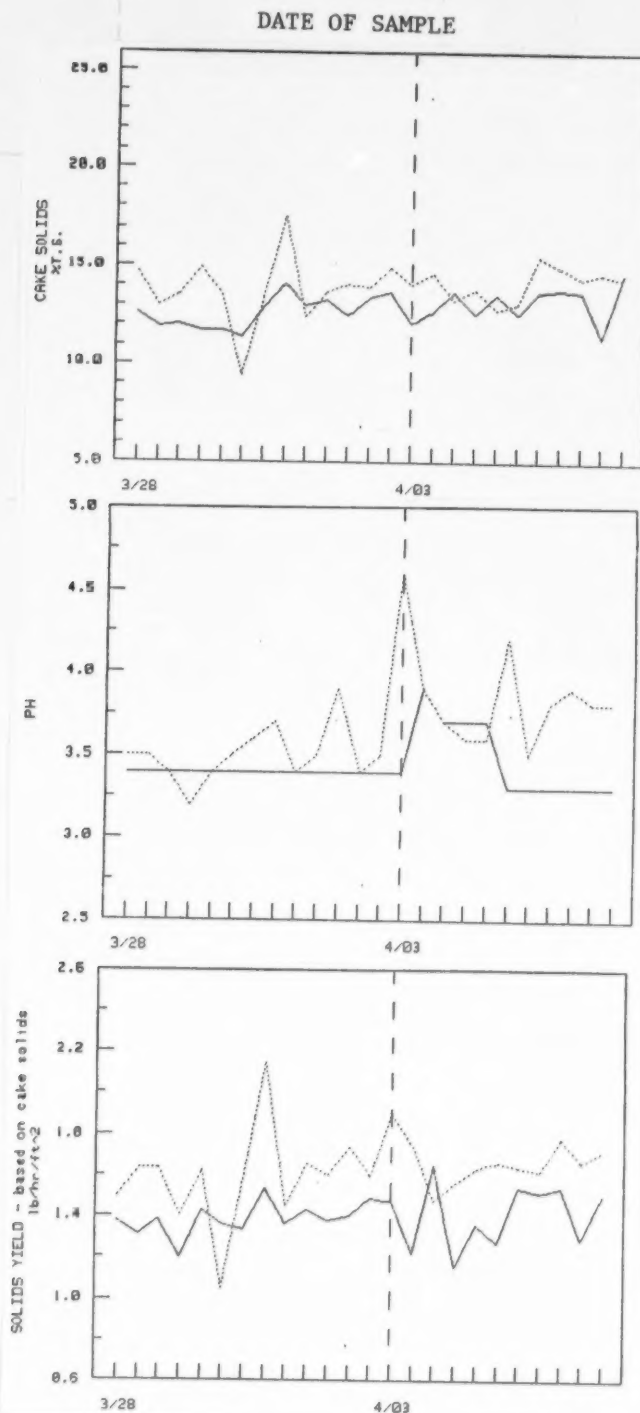


Figure 29. Plots of solids yield, pH and cake solids for the study periods beginning on the dates shown above. Each tick represents one paired observation. (—) experimental bottom feed filter). (---) production filter; ---experimental bottom feed filter).
 $4.89 \text{ kg/hr/m}^2 = 1 \text{ lb/ton/ft}^2$.

It may then be concluded that reducing the shear forces that disrupt floc particles will improve sludge dewatering characteristics.

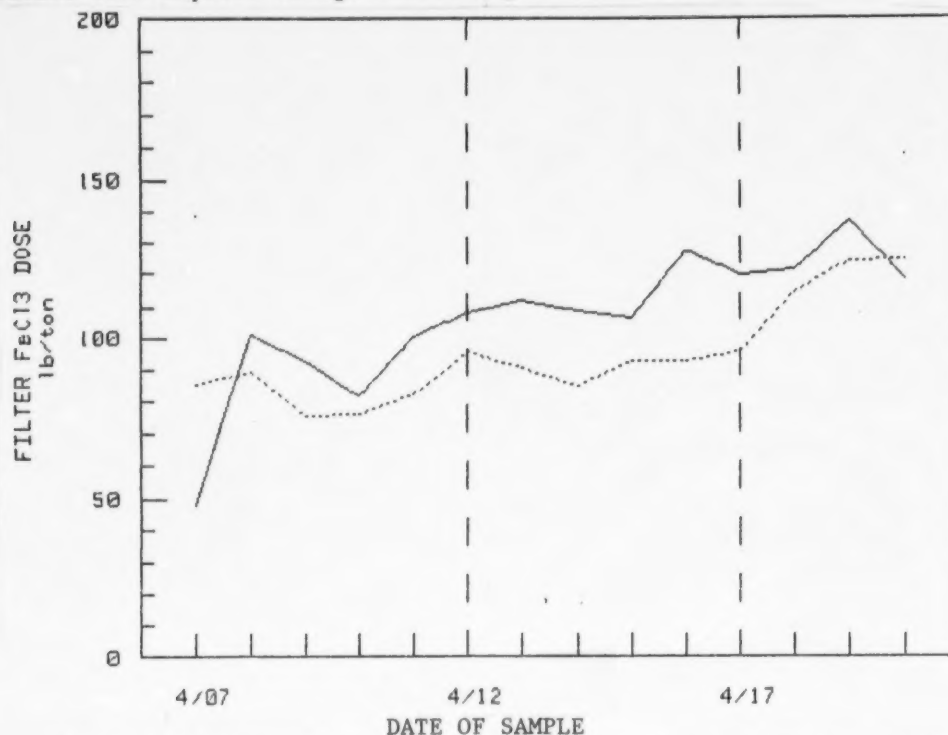


Figure 30. Plot of ferric chloride dosage for the study periods beginning on the dates shown above. Each tick represents one day (-top feed filter; ---MMSD production filter)

0.5 kg/metric ton = 1 lb/ton.

THE IMPACT OF CONTINUOUS OPERATION ON THE TOP FEED FILTER PERFORMANCE

Current operating procedures at the Jones Island Sewage Treatment Plant call for the production filters to be shut down and washed every 100 hours with water from high pressure spray nozzles. This is done to keep the filters operating at a maximum level of performance. In order to determine the optimum washing frequency of the top feed filter, the top feed filter was operated at a constant solids loading rate (operation mode 3). The top feed filter was monitored over the length of the study period to determine the impact of continuous operations on the performance of the filter. The bottom feed filter was operated at an equivalent flow rate as a control. The data from these study periods would thus indicate what changes if any would be expected in the top feed filter performance during continuous operation. During all four study periods discussed here both filters were treating sludge conditioned by the Jones Island Acid House. Table 10 presents the results from the four study periods.

The top feed and bottom feed filters were operated over 100 consecutive hours during only one of the four study periods listed in Table 10. The data collected during the other three study periods are useful only in

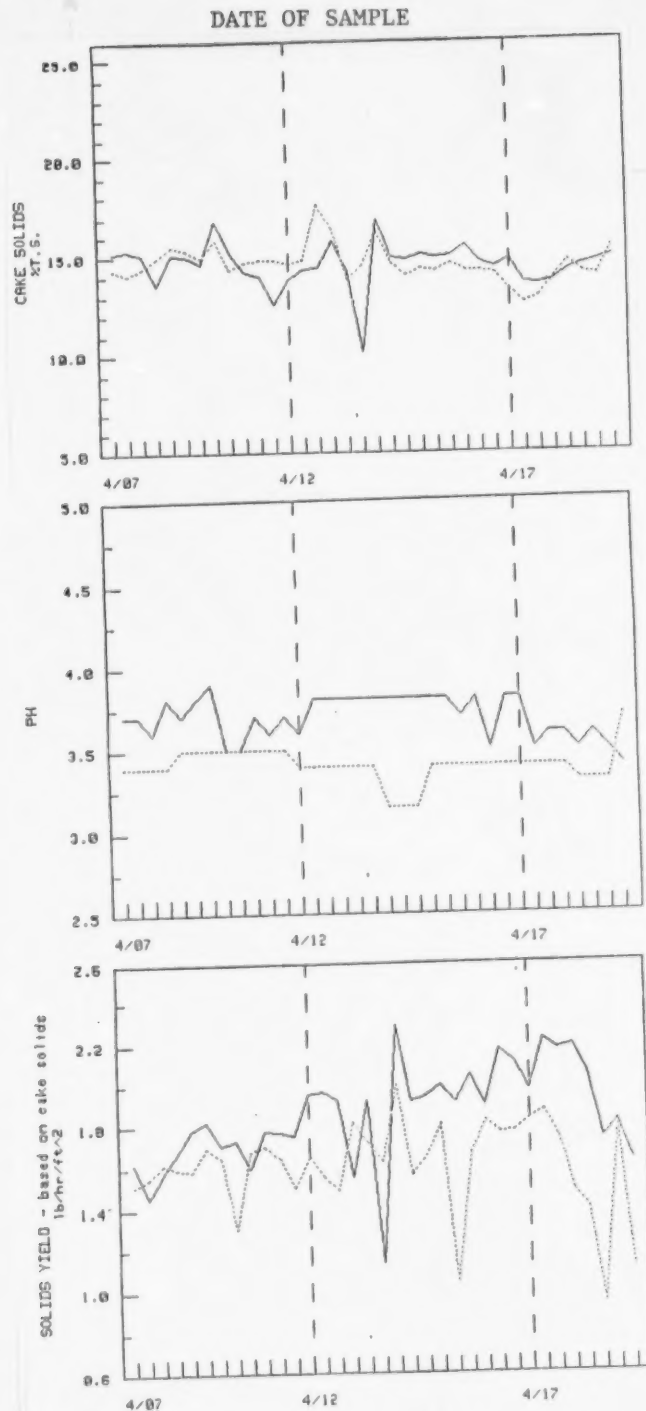


Figure 31. Plots of solids yield, pH and cake solids for the study periods beginning on the dates shown above. Each tick represents one paired observation (-Top feed filter; ---MSD production filter) 4.89 kg/hr/m² = 1 lb/hr/ft²

determining how the performance of the top feed and bottom feed filter varied during the normal 100 hour cycle. Figure 32 shows the variation of solids yield, form time, and cake solids for all four study periods. During all four study periods the solids yields based on cake solids were statistically higher from the top feed filter, while the solids yields based on sludge flow were equivalent. The difference in these values reflects some experimental error, however, where there is a large difference between solids yields calculations it is indicative of the amount of blinding present on the filter. For example, if 10 percent of one filter surface is blinded while the other filter is only 2 percent blinded and both filters are operating at equivalent loading rates then one filter is treating sludge on 8 percent less surface area. The result is a higher solids yield when computed from the mass of solids in the filter cake sample. The solids yield based on sludge flow would be the same for each filter. The solids yield based on sludge flow rate may be considered an average yield for the entire filter surface area, blinded and non-blinded. The filter yield based on cake solids when combined with the results of the cake solids (percent total solids) analysis represents the degree of dewatering capacity that can be expected if the whole filter surface is covered with filter cake equivalent to that in the filter cake sample. Thus when discussing the performance of the filter in terms of filter yield and cake solids it is more appropriate to refer to the solids yield based on cake solids. Because of the higher solids yields on the top feed filter, the cake solids were on the average always lower than the bottom feed filter cake solids. In the study period beginning on 3/8, the bottom feed cake solids were statistically higher. However, for the other three periods there was no statistical difference.

When evaluating the performance decline during the 170 hours of consecutive filter operation during the study period beginning on 3/8, it is quite obvious that as the pickup time is increasing over the duration of the study period that the cake solids are decreasing on both experimental filters. Some of this decrease may be due to the increase in solids yield, but even when the solids yield decreases the cake solids still continue going down. An increasing form time is the most obvious response to the continuous operation of the experimental filters and is probably the result of solids accumulating in the weave of the cloth along with slime growth. The cloth becomes progressively more resistant to filtrate flow and as a result a longer pickup time is required for a given loading rate.

Neither filters performance appears to decline at a faster rate than the other filter. The filtrate quality does not appear to be affected by the length of operation. A graph of filtrate suspended solids for all four study periods is presented in Figure 33. The major problem associated with operating the top feed and bottom feed filters for over 100 consecutive hours between water washings is the accumulation of slime growth and solids in the weave of the filter cloth. This leads to blinding of the filter cloth and a reduction in the performance of the vacuum filter. Based on the data collected during the study periods discussed above the top feed filter provides no significant advantage in terms of extended continuous operation. The 100 hour washing cycle appears to be the best way to maintain an optimum performance from the top feed filter.

TABLE 10. SUMMARY OF RESULTS FROM THE TOP FEED FILTER AND
BOTTOM FEED FILTER DURING OPERATION OF A CONSTANT
LOADING RATE

Study period	Consecutive hr of operation ¹		Loading rate, gpm		Form time, sec		Solids yield ² , lb/hr/ft ²		Cake solids, %		Filtrate suspended solids, mg/l		Feed solid, mg/l
	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	
3/1/80-3/6/80	53	34	104	112	46	51	1.46	1.28	13.97	14.36	82	46	14,180
	67	95					(1.27)	(1.29)					
3/8/80-3/11/80	73	93	130	123	52	62	1.43	1.26	13.55	14.04	137	84	13,600
							(1.44)	(1.37)					
3/12/80-3/17/80	32	23	104	103	43	40	1.35	1.15	15.20	15.98	88	52	14,520
	4	103					(1.25)	(1.23)					
	19												
	23												
	17												
3/18/80-3/27/80	170	173	109	111	49	51	1.56	1.38	14.26	14.59	68	63	15,310
	46	43					(1.40)	(1.43)					

¹Shutdown due to belt repair seal replacement on top feed and filter blinding reduced the length of continuous operation in some study periods.

²Solids yield based on cake solids. Numbers in parenthesis represent solids yield based on sludge flow rate.

3.785 liters/min = 1 gal./minute

4.89 kg/hr/m² = 1 lb/hr/ft²

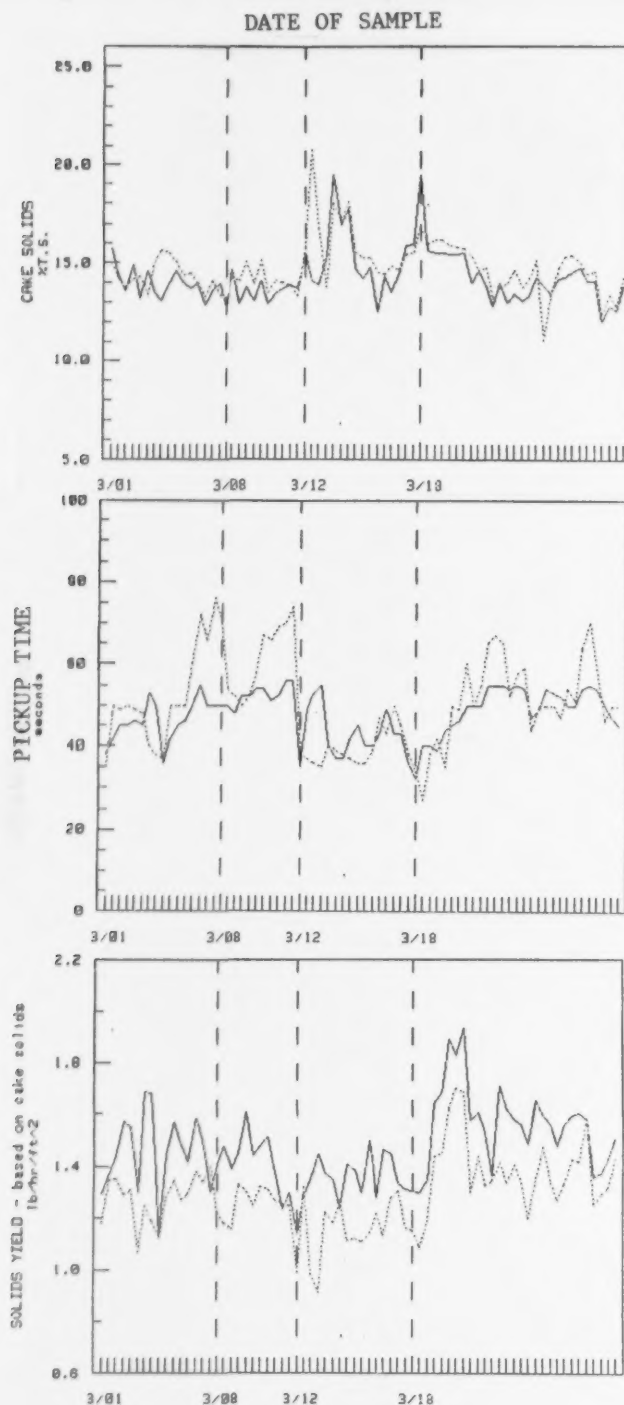


Figure 32. Plots of solids yield, pickup time and cake solids for the study periods beginning on the dates shown above. Each tick represents one paired observation ($4.39 \text{ kg/hr/m}^2 = 1 \text{ lb/hr/ft}^2$).

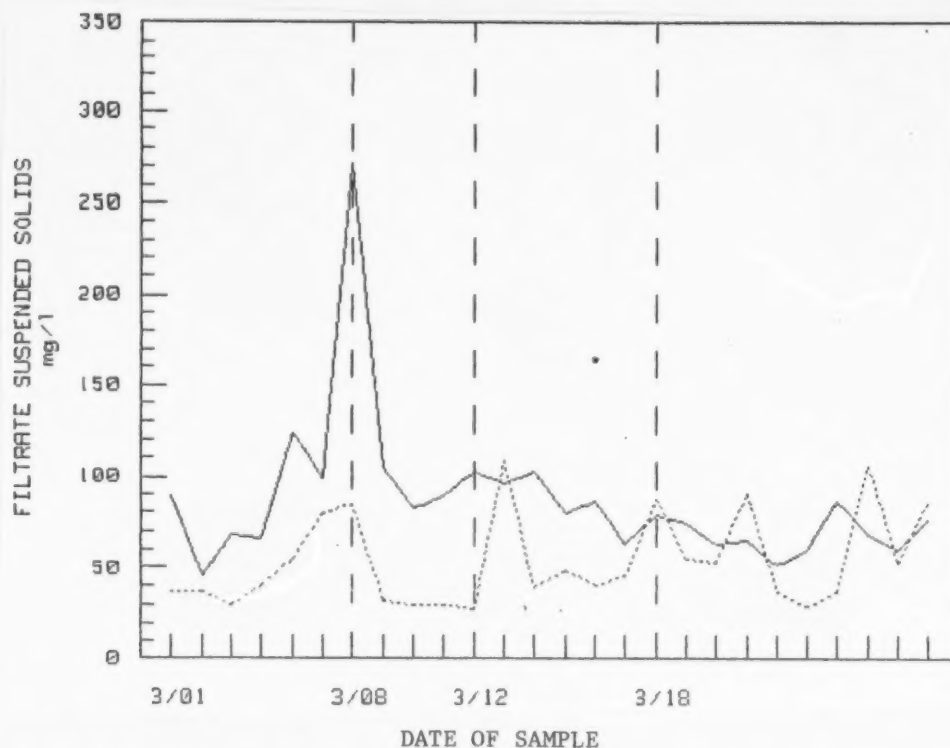


Figure 33. Filtrate suspended solids from the top feed and bottom feed filter for the study periods beginning on the dates shown above. Each tick represents one day.

MAINTENANCE REQUIREMENTS OF THE TOP FEED FILTER AND BOTTOM FEED FILTER

The top feed vacuum filter by nature of its design has unique maintenance requirements. These maintenance requirements are associated with the seals and wear sheet used on the top feed sludge hopper. These items wear gradually because of their contact with abrasive sludge materials, filter cloth, and the filter drum seal surface (Figure 3).

The regular maintenance associated with a bottom feed vacuum filter would also apply to a top feed filter except for maintenance associated with the agitator used to prevent solids deposition. The top feed filter does not require an agitator. Lubrication of the drum bearings and gear reducer would be identical for both filters. The scraper blade on the top feed filter was replaced at more frequent intervals than the bottom feed filter scraper blade during the full-scale evaluation period, but this was due to an improper design. There should be no reason for replacing the blade on the top feed filter at a more frequent interval when one considers the fact that both scraper blades wear on identical filter cloths.

The polyolefin wear sheet and extruded seal materials have to be replaced at regular intervals if the top feed filter is expected to perform satisfactorily. The wear sheet is held in position by a series of metal brackets. When the wear sheet is replaced these brackets must be removed and a new piece of wear sheet inserted. There are no special tools required for the task, and it can usually be completed in one to two hours. Regular replacement of this wear sheet is essential to prevent leaks from occurring along the bottom of the sludge hopper. These leaks can cause excessive blinding and lower overall cake solids production.

During the top feed filter evaluation the major maintenance item was the polyolefin wear sheet. The original wear sheet was only 0.010 inches (0.25 mm) thick and would rapidly wear out. Sludge would then leak through causing operational problems. Positioning extra pieces of wear sheet material would extend the life of the seal for only a short time. Thicker polyolefin wear sheet material that was 0.030 inches (0.76 mm) thick was then substituted for the thin wear sheet and extended operation of the filter was possible. The frequency of wear sheet replacement was reduced from a weekly basis to once every six to eight weeks. Small patches of wear sheet material were positioned between the main seal and the high wear points such as the cloth seams and hopper corners. When these patches wore through and a leak developed they could easily be replaced.

Positioning the wear sheet and anchoring it properly was also found to be critical to good performance. If the wear sheet was not flat against the seal, when the hopper was positioned against the filter, then a crease would develop and leaks would appear almost immediately. Usually a patch would prevent further leakage past the crease. If the seal was not anchored properly the tension placed on the wear sheet by the rotating drum would pull the wear sheet out of position and cause creases to develop between the properly anchored section and the loose section of wear sheet. Leaks would also develop quickly in this case. If a large section of the wear sheet pulls loose then the entire wear sheet has to be replaced because the creases are too big to patch over. It is always quicker to apply a patch to a worn or creased portion of the wear sheet, but in cases where there is significant damage to the wear sheet it is better in the long run to replace the entire wear sheet.

The extruded seal that is placed between the sludge hopper and the filter drum does not wear as rapidly as the wear sheet. The expected replacement interval is once every six months. Metal brackets also hold the seal to the sludge vat and these must be removed before the seal is replaced. No special tools are required for this task either.

Based on observations made during the full-scale evaluation, the top feed filter cloth will need to be replaced every year. The wear on the cloth from the wear sheet produces many small holes and as a result reduces the filtrate quality. The normal cloth life for a bottom feed filter is between five and ten years. The cloth replacement procedure for the top feed filter is only slightly different from the bottom feed filter. The caulking ropes that hold the filter cloth in position at each end of

the filter have to be covered with RTV or stainless steel strips to prevent leakage. Filling in the grooves with RTV is a simple procedure requiring approximately four hours to complete.

The extra wear on the top feed filter cloth discussed above did not have a significant effect on the filter cake solids or solids yield. A five foot by six foot section of old filter cloth was removed from the top feed filter and a new piece of filter cloth was sewn in to replace it.

A comparison of the filter cake solids and solids yield from the new filter cloth and old filter cloth was performed during the last week of the study. The results are presented below in Table 11.

The results of a statistical analysis of the data in Table 11 indicates there was no significant difference between the cake solids or the solids yield from the old filter cloth and new filter cloth. The analysis was made using a student t-test at a 95 percent confidence interval.

TABLE 11. TOP FEED FILTER CAKE SOLIDS AND SOLIDS YIELD FROM COMPARISON OF NEW FILTER CLOTH AND ORIGINAL FILTER CLOTH

Date	Cake solids, %		Solids yield ¹ , lb/hr/ft ²	
	New cloth	Old cloth	New cloth	Old cloth
8/1/80	16.3	15.8	1.45	1.45
8/2/80	15.0	15.8	1.54	1.69
8/3/80	15.3	15.6	1.68	1.55
8/4/80	16.7	16.8	1.47	1.45
8/5/80	17.9	17.9	1.64	1.52
8/6/80	17.4	17.2	1.92	1.78
8/7/80	14.9	15.5	1.85	1.70
Average	16.1	16.3	1.65	1.59

¹ Solids yield based on filter cake solids.

(4.89 kg/hr/m² = 1 lb/hr/ft²).

SECTION 8

COST-BENEFIT ANALYSIS OF THE TOP FEED FILTER

To compare the cost of operating a top feed filter with the cost of operating a bottom feed filter, only those differences in costs unique to each filter type were considered. Both types of filters are identical with respect to types of drum, bearings, drives, internal piping, valving, external piping, and support equipment, therefore, these costs would be the same for each filter. The differences between the two types of filters are the sludge hopper, use of an agitator in the bottom feed sludge vat, the vat and seals.

The top feed filter uses an epoxy coated carbon steel hopper instead of a vat. The bottom feed filter requires a complete stainless steel or an epoxy created carbon steel vat to contain the sludge, whereas the top feed filter requires only half of a vat. The top feed filter trunnion supports are connected by the half vat to provide rigidity to the machine. The top feed filter does not require a vat agitator and associated controls, since settlement of sludge actually enhances formation of filter cake on the drum. Seals are required for a top feed filter, however, and a special die would be required to make the recommended extruded seal.

The capital costs associated with the differences between the two types of filters are summarized in Table 12. The prices were provided by the manufacturer of the two filters used in the performance of this project, and apply to those filters actually supplied. Seal tooling costs apply to a new die, however, the existing die could possibly be modified for less than a new die. Tooling costs have a negligible effect on the total cost of top feed filtration. All of the capital equipment prices shown are 1980 selling prices, which were obtained by correcting the 1977 prices for inflation.

The operating costs which apply only to the differences between top feed and bottom feed filters are based on experience gained during this project. Other operating costs, such as lubrication, drum rotation power, acid washing, etc., are not considered here because they would be identical for both types of filters.

Seal and cloth replacement are the major operating cost differences between the two types of filters. Operating experience has shown that the extruded seals (peripheral and horizontal) will last for longer than 6 months. The horizontal seal (wear sheet) must be replaced at 2 month intervals. Replacement of the extruded seals consumed 6 manhours, while replacement of the horizontal seal (wear sheet) normally consumed 2 manhours. Material costs were based on 1977 prices corrected for inflation and 1980 seal

TABLE 12. COMPARATIVE COSTS SUMMARY TOP FEED FILTER vs. BOTTOM FEED FILTER

Cost item	Top feed filter	Bottom feed filter
<u>Capital costs</u>		
Hopper and frame (installed)	\$14,700	
Agitator, electrical controls		\$15,400
Vat shell half		\$16,000 ¹
Seal tooling	\$650	\$7,000 ²
Total capital costs	\$15,350	\$31,400
<u>Operating costs (per year)</u>		
Extruded seal (2 per year)	\$240	
Wear sheet (6 per year)	\$80	
Seal replacement labor (24 man-hrs/yr)	\$312	
Cloth	\$250	\$48
Cloth replacement labor (16 mos/hrs)	\$208	\$36
Power for seal drag	\$30	
Power for agitator		\$70
Total operating costs	\$1,120	\$154
Amortization (20 yrs @8 %)	\$1,562	\$2,280
Total annual cost	\$2,682	\$3,350
		\$2,434

¹Price of sludge vat if constructed of 316 stainless steel.²Price of sludge vat if constructed of carbon steel.

material purchases. Labor costs are based on an average 1980 labor rate of \$10.00 per hour plus a 30 percent fringe benefit program.

Top feed cloth replacement will be necessary every year, due to wear caused by seal drag. Bottom feed cloth replacement was assumed to be necessary every 5 years. The "sinking fund" factor for 5 years at 8 percent interest was used to establish the annual amount that must be set aside to pay for the labor and materials required every 5 years. Inflation was not considered.

The power required to overcome top feed drag was estimated at 0.112 KW (0.15 HP). Seal drag was calculated from experimental coefficient of friction values multiplied by the sludge pressure against the seals. Peripheral seals rubbing on stainless steel have a coefficient of friction of 0.53. The horizontal seal (wear sheet) has a coefficient of friction of 0.22. A drum speed of four minutes per revolution (0.25 RPM) was assumed in the power calculation.

Bottom feed agitator power was estimated by multiplying the agitator drive motor rated power by actual strokes per minute squared and maximum strokes per minute squares. The agitator is capable of 20 strokes per minute while drawing 2.2 KW (3 HP), the full rated power. The agitator was operated at 7 strokes per minute. The ratio of strokes per minute squared was used as a factor in calculating agitator power since agitator drag is a function of velocity squared. The power for agitating sludge was estimated at 0.27 KW (0.36 HP). Power cost was based on a power cost of \$0.03 per KW-hour and 360 days of operation per year. From Table 12, it can be seen that the power costs are small in relation to overall operating costs.

Ammortization of capital costs is based on 20 year life at 8 percent interest. No salvage value is considered, since the equipment would have negligible value as scrap iron when no longer used.

Based on the filter cake solids summarized in Table 2 one would not expect any significant difference between the top feed filter and bottom feed filter performance at a four minute cycle time. Although the solids yields based on cake solids in Table 2 show the top feed filter to have a 5 to 10 percent higher yield, the yield based on sludge flow shows the top feed to have a 0 to 5 percent less yield. Using the more conservative solids yield data (solids yield based on sludge flow) and assuming both filters had equivalent solids yields, then the top feed filter operating cost would be approximately \$250 a year greater than the bottom feed filter operating costs. If a stainless steel vat was used on the bottom feed filter instead of a carbon steel then the top feed filter operating cost would be approximately \$670 dollars less than the bottom feed filter operating cost.

Based on these comparisons the top feed filter can be expected to perform as well as a bottom feed filter with a slightly greater operating cost. If the top feed filter operates at peak solids yield (as calculated by cake solids) then it would provide a 5 to 10 percent increase over the bottom feed filter without sacrificing a loss in cake solids. This would allow the use of fewer filters to treat a given sludge flow.

SECTION 9

ECONOMIC, OPERATIONAL AND DESIGN ASPECTS OF THE TOP FEED FILTER

This study of the prototype top feed vacuum filter has produced significant data to evaluate the economic, operational and design aspects of the top feed filter. Based on the data presented in this report the top feed filter produced higher solids yields at a given pickup time than the bottom feed filter. At a 3 minute and 40 second cycle time the top feed filter was found to produce higher cake solids than the bottom feed filter, however, at a 4 minute cycle time the top feed filter did not produce higher cake solids than the bottom feed filter. The optimum cake saturation level was found to be similar for the top feed filter and bottom feed filter; however, the top feed filter was able to reach this cake saturation level earlier in the filter cycle. This is a result of the higher driving force available to the top feed filter in the pickup zone. The top feed filter makes available more of the driving force of the applied vacuum for filter cake formation because of its basic design configuration.

A comparison of central sludge conditioning and local sludge conditioning determined that there is some negative impact on the dewaterability of sludge when distributed through long piping networks. It is apparent that the filter conditioning should be done as near the vacuum filter as possible.

The performance of the prototype top feed filter was evaluated using one of the more difficult sludges to dewater - waste activated sludge. With the top feed filter's relatively high yield and shorter cycle time, it would be reasonable to assume that the top feed filter could perform as well as or better than a bottom feed filter on other types of sludges.

In order to obtain these high solids yields on the top feed filter, a significantly greater amount of routine maintenance is required. The seals, wear sheet and filter cloths all need to be replaced at regular intervals to maintain efficient operation. However, the top feed filter does have lower capital cost. Table 12 shows the capital cost for the top feed filter to be \$7,000 less per filter, but the additional maintenance requirements for the top feed filter cost \$1,000 more per year per filter. Combining the amortized capital costs and yearly maintenance costs shows the top feed filter to have a higher net cost of operation per year. The difference between costs being \$250 per year per filter. However, these costs per filter may be offset by the somewhat higher solids yield available from the top feed filter.

The additional maintenance costs may be reduced by modifications to the prototype top feed filter. With these changes the top feed filter could potentially maintain a high level of performance for longer periods and with less maintenance. A review of the prototype top feed design is presented below. A discussion of improvement in the prototype design follow:

1. Top feed seal - The necessity of a flat seal proved to be correct. The buckling problem experienced with earlier seals was solved. Having the groove on top of the seal allowed the use of a tension wire and turnbuckle to increase seal pressure. The seal worked fine initially, but loss of natural tension caused the peripheral seal to leak. Tightening the tension wire with the turnbuckle eliminated the leakage.

The seal material, a polyethylene/polypropylene copolymer, were well and exhibited good chemical resistance. About six months of wear can be expected before seal replacement. Wear on the drum sealing surfaces was about 1/32 (0.79 mm) inch after 12 months of operation. The drum wear surface was an epoxy coating.

The smaller than desirable seal width did not prove to be a disadvantage. The seal was easily heat welded at the corners by melting the joint surfaces and holding the parts together until bonded. This operation takes about 30 minutes. A prewelded seal can be installed by two men in less than six hours.

The only problem experienced with the peripheral seal was the accumulation of fibrous material between the seal wear surfaces. This material built up until leakage occurred. Cleaning out the buildup with a hooked tool was necessary to clear the buildup.

2. The "L" seal (wear sheet) worked better than expected, however wear was a problem on the initial 0.010 in. (0.25 mm) thick seals. By using HMW 1900 polyolefin in 0.020 and 0.030 inch (0.51 mm and 0.76 mm) thickness, the 2 week seal life was extended to 2 months. Seal wear was greatest at the lower, hopper corners and at the media cloth seams. Small patches of seal material (wear sheets) placed in these areas extended the seal life by taking the wear. The worn patches were replaced when inspection revealed that holes were worn in them.

Another problem experienced was the embrittlement of the horizontal exteneed seal. Leakage occurred after some time when the plastic seal material became brittle. Mechanical seal pressure was applied by stainless steel leaf springs inserted behind the seal as shown in Figure 3. These springs were made from 0.003 inch (0.075 mm) shim stock. Placing these 2 inch (5.1 cm) long springs behind the seal wherever leakage existed solved this problem.

3. The top feed hopper was built stiff enough to resist deflection away from the drum due to sludge pressure. The seal mounting lip

was almost a perfect straight line. Sludge distribution was good, as no stagnant dead spots were observed.

The only problem experienced with the sludge hopper was the difficulty of movement and adjustment. Jackscrews were used to move the hopper toward or away from the drum for seal adjustment. When seals were replaced, the hopper was moved about 3 inches (7.6 cm) from the drum for access. The jackscrew threads failed on three occasions, making jackscrew replacement necessary. Larger jackscrews should be used on any future designs.

The slotted bolt holes also were a problem. If longer bolt hole slots were used, the hold down bolts would not have to be removed whenever the hopper was moved.

Vertical (peripheral) adjustment was impossible with the hopper support as designed. The hopper support should have been built lower and then raised with shims between the filter frame and the support frame. Shims could be added or removed to accurately locate the hopper for best seal position.

Figure 34 shows the recommended hopper improvements.

RECOMMENDATIONS FOR FUTURE TOP FEED FILTERS

After operating the full-scale top feed filter, improvements to some of the features could be found. Some of the most essential improvements can be listed as follows:

1. Top feed seal - The basic seal configuration is adequate, however, the wear surfaces should be redesigned. The extruded seal should have a cross section as shown in Figure 35 which would resist fiber buildups. Even if fiber did build up under the seal, it could be removed easily since the shape would not trap the fiber as the present seal slot does.
2. Filter drum wear surface - The caulking strip on the edge of the drum is required to hold the media cloth in place. However, the caulking groove was a continuous source of leakage even when filled with a silicone rubber caulking compound. The drum wear surface should be located over the caulking strip. The seal ring could be eliminated from the drum, resulting in lower cost.
3. Horizontal seal - The 0.030 inch (0.76 mm) thick HMW polyolefin "L" seal (wear sheet) lasted longest. Media seams should be eliminated or reduced in thickness to eliminate the localized wear. By changing to a seal configuration shown in Figure 35, corner localized wear may be reduced. Seal pressure should be reduced at the corners to reduce "L" seal water.

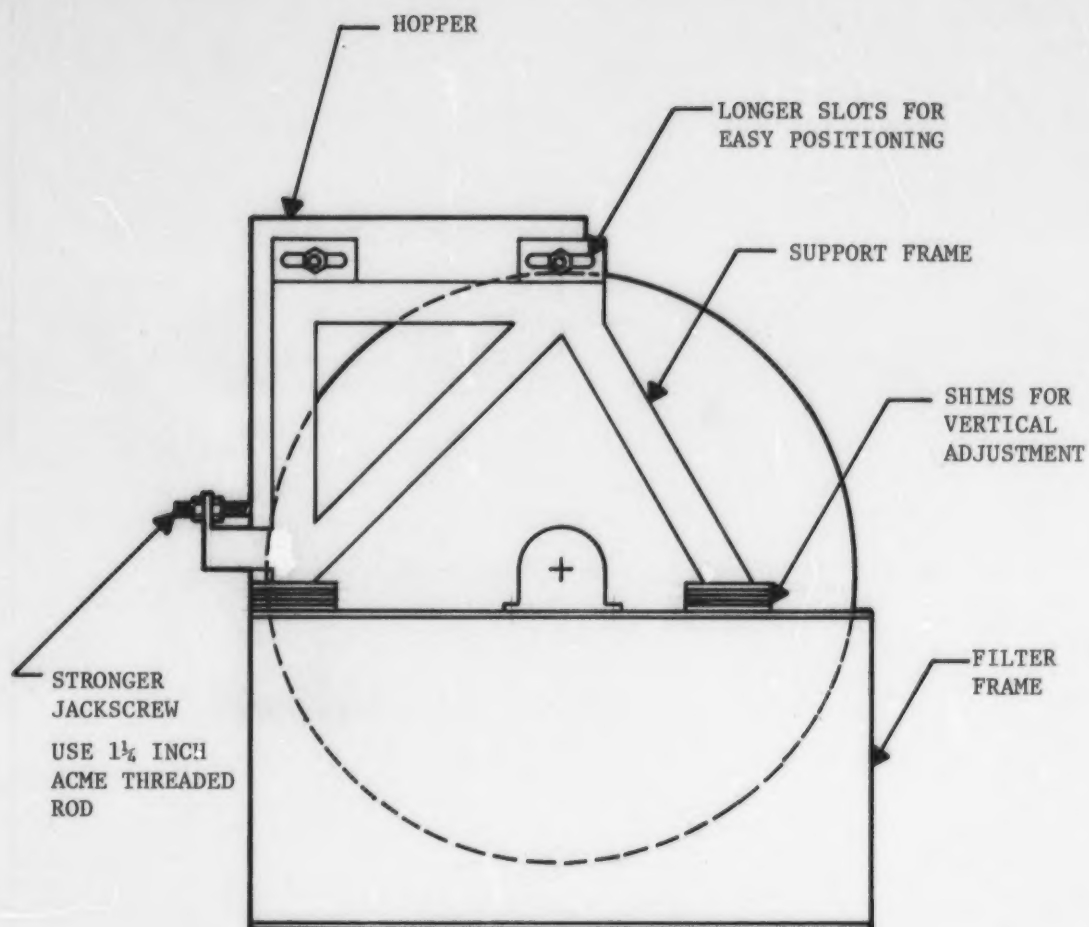


Figure 34. Hopper support.

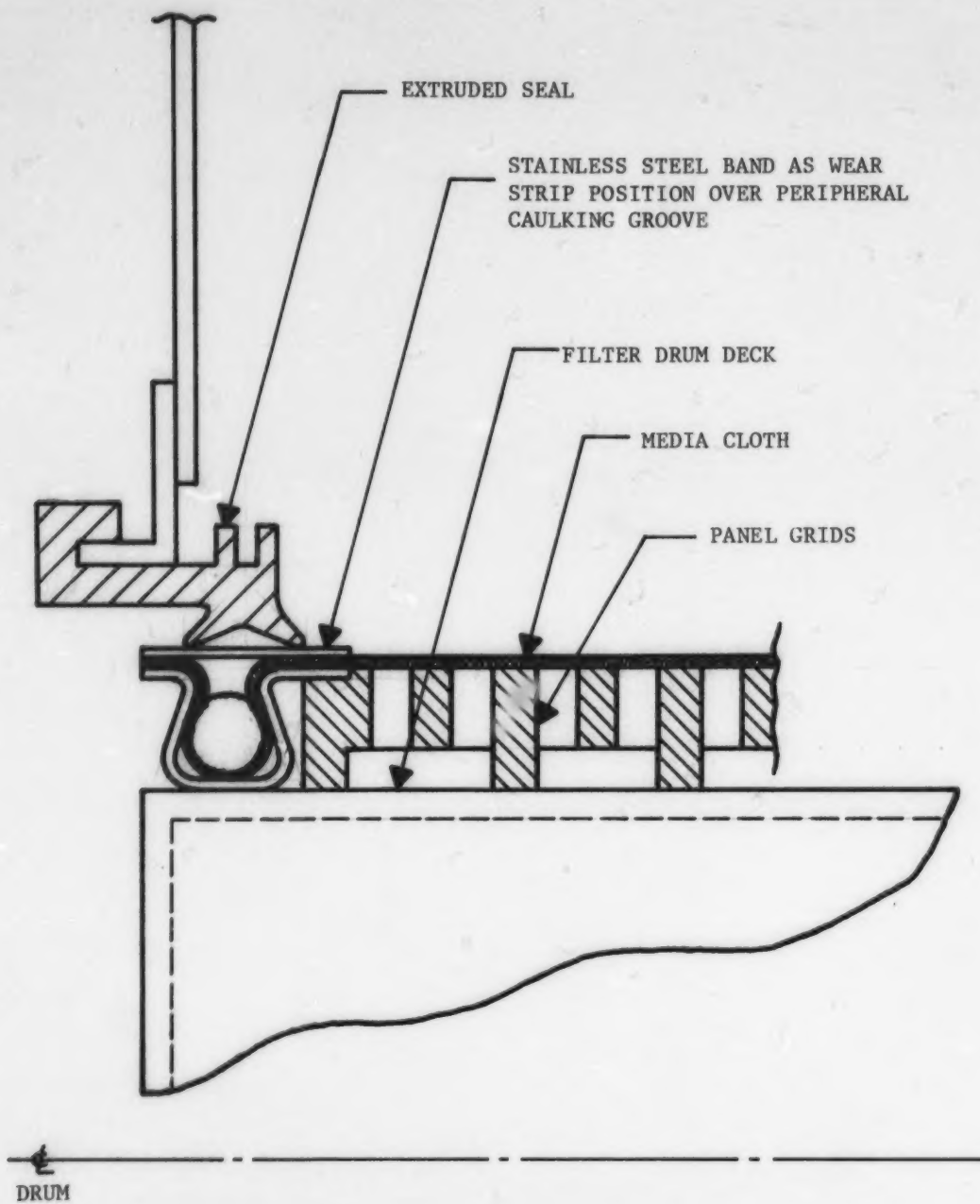


Figure 35. Proposed seal and wear surface for future top feed filter design.

The horizontal extruded seal could not be eliminated. There is no vertical force to counteract the weight of sludge if horizontal seal is removed. Consequently, sludge pressure would push the wear sheet out the bottom of the hopper.

4. Hopper - Provide strong jackscrews and long slots for convenient movement of the hopper. Locate piping, handrails, steps, etc., away from the seals so access will not be impaired.
5. Leak control - Provide a 6 inch (15.2 cm) curb around the base of the top feed filter to collect leakage and cleanup overspray. Pitch the flooring in the area toward a floor drain. Remember, there is no vat under a top feed filter to contain sludge and backwashings.

SECTION 10

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APPENDIX A

LABORATORY ANALYTICAL PROCEDURES

The following analyses were performed according to Standard Methods for the Examination of Water and Wastewater (Fourteenth Edition).

Cake Solids

Section 208G. Procedure a.l.c. Results expressed as percent total solids.

Feed Sludge Total Solids

Section 208A. Results expressed as mg dry solids/liter feed sludge.

Filtrate Suspended Solids

Section 208D. Results expressed as mg suspended solids/liter filtrate.

Filtrate Iron Content

Section 301A.II.1. Results expressed as mg Fe/liter filtrate.

Stock Ferric Chloride Iron Content

Section 301A.II.1. Results expressed as mg Fe/liter filtrate.

Buchner Funnel Test

The Buchner Funnel test produces the data necessary to determine the specific resistance of a slurry, an indicator of filterability. This test is quicker than a leaf test and thus is used to supplement the leaf for the preliminary data.

The apparatus required is a Buchner funnel, filter paper or selected filter media, vacuum supply, rubber hoses, vacuum bottle, vacuum gauge and general laboratory equipment.

1. Moisten filter paper and place it in the Buchner funnel. Apply a vacuum to obtain a seal. Empty water collected in filtrate receiver.
2. Analyze the sludge to be filtered for solids content.
3. Measure a volume of sludge equivalent to approximately 5 grams dry solids for activated sludge or 7.5 grams dry solids for a primary sludge in a volumetric flask.
4. Add the sludge to the funnel and quickly apply vacuum. As soon as vacuum is applied, start the stopwatch. A vacuum reservoir may be needed to hold a constant vacuum.

5. Take filtrate volume readings with respect to time.
6. Continue the test until the cake cracks, or no filtrate is deposited for a one minute interval. Usually five minutes is a sufficient time. Be sure the cake edges do not shrink from the sides of the Buchner funnel. If it does, tamp the edges of the cake to maintain a seal.
7. Sample cake for total solids.
8. Record filtrate temperature, vacuum level, and cake thickness.
9. Plot a curve of time/volume filtrate vs. volume filtrate and record the slope of the curve. The slope recorded should include only the linear portion of the curve.
10. Calculate specific cake resistance from the formula:

$$r = 2PA^2/\mu\omega$$

Where:

- r = Specific resistance in sec^2/gm .
 - p = Vacuum level in gm/sq cm .
 - A = Area of Buchner funnel in sq cm .
 - b = slope of t/v vs. v curve in sec/cm^6 .
 - μ = Viscosity in centipoise.
 - $\omega = 1/[(C_i/(100-C_i)) - (C_f/(100 - C_f))]$ in gm/cm^3 .
 - C_i = Initial sludge moisture concentration (percent).
 - C_f = Moisture concentration in cake (percent).
- $(9.81 \times 10^3 \text{ sec}^2/\text{gm} = 1 \text{ m/kg})$

APPENDIX B

STATISTICAL PROCEDURES

The following statistical procedures were used for data analysis in this report.

STUDENT T-TEST (PAIRED COMPARISON TEST)

A two-sided student t-test is used in this report to determine if the means of paired independent observations are equal. The initial hypothesis for the two-sided test is that the mean of the two populations are equal at a given confidence level. In this case a 95 percent confidence level. If the calculated t-value is less than or equal to the absolute value of t then the means are equal (null hypothesis). If the calculated t value is greater than the absolute t value, then the means are not equal and the null hypothesis is rejected. In rejecting the null hypothesis it is concluded that there is a systematic difference between the means.

The advantage of the paired comparison test is that the limits for the average difference and the test of significance for the observed difference, are based only on the variation in the differences. Other variations which may have equal effects on the paired observations do not influence the accuracy of the comparison.

The formulas for calculating the student t are given below:

$$\begin{array}{ll} X_1 = \text{Data population 1.} & \bar{X}_1 = \text{Mean of population 1.} \\ X_2 = \text{Data population 2.} & \bar{X}_2 = \text{Mean of population 2.} \\ dj = \text{Difference between paired observation from population 1 and 2.} & \\ \bar{d} = \bar{X}_1 - \bar{X}_2 & k = \text{Number of observations.} \\ S_d^2 = \frac{\sum (dj - \bar{d})^2}{k-1} & S_d = \sqrt{S_d^2} \\ t = \frac{(\bar{d})(\sqrt{k})}{S_d} & \end{array}$$

Reference: Statistical Analysis in Chemistry and the Chemical Industry, Bennett and Franklin, p. 180-3.

LINEAR LEAST - SQUARES REGRESSION ANALYSIS

A linear least-squares regression analysis is used to determine if a significant correlation between two variables exists. This test consists of fitting a line to a set of data points using a least squares analysis. After this is done the data is analyzed to determine if one variable is predictable from the other. Depending on the degree to which one variable may be predicted from another a correlation is then calculated. A high correlation indicates one variable predicts accurately what the other variable is, while a low correlation indicates one variable is unpredictable from the other variable.

Based on the number of observations the significance of the correlation is then determined. A t value is calculated by the following equation where n = number of observations and r = correlation coefficient.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

This calculated t value is compared to an absolute t value at a 95 percent confidence level. If the calculate t is greater than the absolute t then a significant correlation exists between the two variables. If the calculated t is less than or equal to the absolute t then no significant correlation between the two variables exist.

Reference: Probability, Statistics, and Random Processes,
Maise], Louis, pp. 162-180.

The filtrate flow rate is accurately measured at all times because it is bubbled through the filtrate through one meter flow meter. However the filtrate flow rate is based on the volume of water present in the filtrate rate. Based on an average cake thickness of 8 mm, a cake specific gravity of 0.95, an average moisture content of 85 percent by weight, and volume of water in the filter cake was calculated to be 15.8 gal./minute. With an average feed flow of 120 gal./minute, the filtrate flow is then approximately 90 percent of the feed solids flow.

APPENDIX C

CALCULATIONS

The following calculations were used in this report.

Ferric chloride dose (mg FeCl_3 /liter sludge):

$$= \frac{(\text{lb } \text{FeCl}_3/\text{gal. stock solution})(\text{gal. } \text{FeCl}_3/\text{day})(10^6 \text{ mg}/2.2 \text{ lb})}{(\text{gallons sludge/day})(3.785 \text{ liters/gal.})}$$

Ferric chloride dose* (lb FeCl_3 /ton dry solids):

$$= \frac{(\text{Ferric chloride dose mg/l})}{(\text{sludge total solids, mg/l})(\text{liter}/2,000)}$$

*Assume 100 percent capture of solids, actual capture is lower.

Filter yield based on cake solids, (lb dry solids/hour/ft²):

$$= \frac{(\text{mass filter cake gms})}{(\text{sampled area ft}^2)} \frac{(1 \text{ lb})}{(454 \text{ gms})} \frac{(\text{filter area ft}^2)}{(\text{cycle time, min})}$$

$$\times \frac{(60 \text{ min})}{(\text{hour})} \frac{(1)}{(\text{filter area ft}^2)}$$

Filter yield based on sludge flow (lb dry solids/hour/ft²)

$$= \frac{(\text{gal. sludge})}{(24 \text{ hrs})} \frac{(\text{mg solids})}{(1 \text{ sludge})} \frac{(3,785 \text{ liters})}{(\text{gal.})} \frac{(1)}{(\text{filter area ft}^2)}$$

Solids recovery (%):

$$= (\text{Feed sludge liter/sec}) \times (\text{total solids g/liter})$$

$$(\text{Filtrate flow liters/sec}) \times (\text{suspended solids g/liter}) -$$

The filtrate flow could not be accurately determined at all times because of air bubbles moving with the filtrate through the vortex flow meter. Instead the filtrate flow was based on the volume of water present in the filter cake. Based on an average cake thickness of 4 mm, a cake specific gravity of 0.95, an average moisture content of 85 percent by weight; the volume of water in the filter cake was calculated to be 12.8 gal./minute. With an average feed flow of 120 gal. sludge/min, the filtrate flow is then approximately 90 percent of the feed sludge flow.

APPENDIX D

TOP FEED FILTER AND BOTTOM FEED FILTER PERFORMANCE

Table D lists date, time of sample, ferric chloride dose (lb/ton dry solids) filter yield-based on cake solids, sludge pH, cake solids (percent total solids), form time (seconds), cycle time (minutes), and filtrate suspended solids (mg/l) for the top feed vacuum filter and bottom feed vacuum filter for the period from 6/26/79 to 8/7/80.

Data under the top feed (TF) filter heading from 3/28/80 (0800 hrs) to 4/7/80 (0700 hrs) and data under the bottom feed (BF) filter heading from 4/7/80 (1500 hrs) to 4/20/80 (0600 hrs) are from Jones Island production filters.

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TABLE D. TOP FEED FILTER AND BOTTOM FEED FILTER PERFORMANCE DATA FOR THE
PERIOD FROM 6/26/79 TO 8/7/80.

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	Fec13 DOSE lb/ton	FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec		CYCLE TIME min		FILTRATE SUSPENDED SOLIDS mg/l	
				TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
06/26/79	1900	18100	-	1.23	1.54	3.80	3.80	17.06	14.20	45	60	4.00	4.00	19	27
	2330	-	-	1.26	1.45	3.80	3.80	16.54	14.60	45	60	4.00	4.00	60	27
	330	16700	-	1.21	1.54	3.80	3.80	17.02	14.20	45	60	4.00	4.00	-	-
	700	-	-	1.28	1.45	3.80	3.80	17.21	14.60	45	60	4.00	4.00	-	-
06/27/79	1000	-	-	1.26	1.41	3.80	3.80	17.22	15.43	45	60	4.00	4.00	-	-
	1300	-	-	1.23	1.42	3.80	3.80	17.13	13.72	45	60	4.00	4.00	-	-
	1600	-	-	1.23	1.39	3.80	3.80	16.08	15.02	45	60	4.00	4.00	-	-
	2000	17000	-	1.25	1.37	3.80	3.80	16.29	14.70	45	60	4.00	4.00	21	20
06/28/79	400	-	-	1.08	1.43	3.60	3.60	14.95	13.77	45	60	4.00	4.00	-	-
	800	-	-	1.26	1.48	3.60	3.60	16.70	14.75	45	60	4.00	4.00	-	-
	1200	-	-	1.32	1.46	3.60	3.60	17.42	15.55	45	60	4.00	4.00	-	-
	1500	-	-	1.23	1.38	3.60	3.60	17.27	15.39	45	60	4.00	4.00	-	-
06/29/79	1900	-	-	1.36	1.31	3.60	3.60	16.10	15.40	45	60	4.00	4.00	-	-
	2300	15000	-	1.24	1.32	3.60	3.60	16.50	15.20	45	60	4.00	4.00	31	34
	600	-	-	1.20	1.36	3.50	3.50	17.10	15.10	45	60	4.00	4.00	-	-
	900	-	-	1.23	1.26	3.50	3.50	16.80	16.10	45	60	4.00	4.00	-	-
06/30/79	1400	-	-	1.29	1.21	3.50	3.50	17.00	15.30	45	60	4.00	4.00	9	22
	2200	15300	-	1.21	1.41	3.50	3.50	16.40	14.90	45	65	4.00	4.00	-	-
	700	-	-	1.24	1.37	3.50	3.50	18.90	18.00	45	60	4.00	4.00	26	43
	1900	-	-	1.17	1.26	3.50	3.50	16.30	14.60	40	60	4.00	4.00	-	-
07/01/79	300	13400	141	1.20	1.37	3.50	3.50	15.80	14.50	39	60	4.00	4.00	-	-
	1000	-	141	1.18	1.35	3.50	3.50	16.20	14.80	38	60	4.00	4.00	42	42
	1800	-	145	1.20	1.32	3.50	3.50	16.00	15.10	40	60	4.10	4.00	-	-
	1600	13100	145	1.08	1.27	3.50	3.50	13.50	15.00	38	60	4.10	4.00	103	103
07/02/79	0	-	-	1.12	1.33	3.50	3.50	16.20	14.70	50	60	4.00	4.00	-	-
	2000	14200	86	1.34	1.34	3.50	3.50	-	14.70	-	60	-	-	-	-
	400	-	86	1.29	1.12	3.50	3.50	15.20	15.40	45	60	4.10	4.00	47	47
	1400	15100	130	1.12	1.43	3.50	3.50	-	13.90	-	60	-	-	-	-
07/03/79	300	-	130	-	-	3.50	3.50	15.30	15.30	45	-	4.10	-	-	-
	1800	-	-	1.36	1.31	3.50	3.50	16.10	16.10	45	-	4.10	-	-	-
	200	15000	145	1.45	1.45	3.50	3.50	15.50	15.50	45	-	4.20	-	-	-
	1030	-	145	1.60	1.60	3.50	3.50	14.90	14.90	45	-	4.10	-	-	-
07/04/79	1700	-	-	1.42	1.42	3.50	3.50	14.40	14.40	45	-	4.10	-	-	-
	200	14600	162	1.57	-	3.50	3.50	14.20	14.20	45	-	4.10	-	-	-
	1800	-	162	-	1.45	3.30	3.30	-	16.00	-	65	-	-	-	-
	900	14200	136	1.28	1.42	3.30	3.30	16.90	16.90	-	62	-	-	-	-
07/05/79	1700	-	136	1.33	1.23	3.30	3.30	15.50	15.10	40	70	4.20	4.00	22	32
	0	14200	144	1.21	1.27	3.30	3.30	14.90	14.90	43	63	4.20	4.00	21	20
	1600	-	-	1.41	1.22	3.30	3.30	14.30	15.10	40	70	4.20	4.00	-	-
	2300	13400	137	1.28	1.25	3.30	3.30	14.60	15.50	48	65	4.20	4.00	-	-
07/12/79	700	-	137	1.33	1.23	3.30	3.30	15.90	15.20	40	65	4.20	4.00	30	25
	1500	-	-	1.21	1.33	3.30	3.30	16.00	15.90	40	65	4.10	4.00	-	-
	2200	-	-	1.37	1.23	3.30	3.30	15.50	15.70	45	60	4.10	4.00	-	-
	600	12800	146	1.17	1.22	3.30	3.30	15.60	15.60	40	60	4.10	4.00	67	41
07/13/79	1400	-	146	1.30	1.11	3.30	3.30	16.60	16.60	40	60	4.10	4.00	-	-
	1430	-15855	148	1.42	1.13	3.30	3.30	14.80	14.80	40	60	4.10	4.00	31	-
	1900	-	148	1.51	1.12	3.10	3.10	14.40	15.80	50	50	4.10	4.00	-	-
	300	13000	172	1.37	1.21	3.10	3.10	15.90	15.90	50	55	4.00	4.00	-	-

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeCl ₃ DOSE lb/ton		FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec		CYCLE TIME min		FILTRATE SUSPENDED SOLIDS mg/l	
			TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
07/20/79	2100	13700	160	160	1.24	.94	3.10	3.10	12.40	13.60	50	50	4.00	4.00	-	-
07/22/79	200	14430	179	179	1.10	.95	3.10	3.10	14.10	14.00	49	52	4.00	4.00	-	-
07/23/79	1600	16100	154	154	-	-	3.10	3.10	-	13.60	-	57	-	-	-	-
07/24/79	2200	18800	145	145	-	-	3.10	3.10	-	15.50	-	50	-	-	-	43
07/25/79	1600	17570	132	132	-	-	3.10	3.10	-	14.10	-	60	-	-	-	70
07/26/79	2100	18970	152	152	-	-	3.10	3.10	-	14.30	-	50	-	-	-	-
07/27/79	2330	18060	179	179	1.27	-	3.10	3.10	13.70	14.10	-	50	-	-	-	-
07/28/79	1815	17860	173	173	-	-	3.10	3.10	-	11.30	-	60	-	-	-	-
07/29/79	1600	20400	158	158	1.14	1.11	3.00	3.00	13.50	13.80	-	50	-	-	-	-
07/30/79	700	20070	166	166	1.12	1.19	3.00	3.00	13.20	12.70	45	50	4.00	4.00	91	80
07/31/79	2200	20050	153	153	1.44	1.25	3.00	3.00	14.90	14.10	54	54	4.00	4.00	-	135
08/01/79	1600	18190	189	189	1.35	1.16	3.00	3.00	14.30	15.10	50	52	4.10	4.00	76	-
08/02/79	2100	18830	155	155	1.31	1.21	3.00	3.00	15.10	15.30	48	52	4.00	4.00	45	190
08/03/79	2130	16900	188	188	1.36	1.18	3.00	3.00	14.60	15.20	50	53	4.00	4.00	40	45
08/04/79	200	16800	181	181	1.37	1.13	3.00	3.00	13.10	15.40	50	49	4.00	4.00	69	90
08/05/79	1000	21070	152	152	1.35	1.14	3.00	3.00	13.10	14.30	50	50	4.00	4.00	94	147
08/06/79	1700	20680	157	157	1.42	1.07	3.00	3.00	13.40	14.40	50	50	4.00	4.00	-	-
08/07/79	800	22340	139	139	1.26	1.02	3.00	3.00	13.10	13.70	60	62	4.67	4.67	73	73
08/08/79	400	19350	179	179	1.39	1.28	3.00	3.00	14.80	14.30	55	60	4.67	4.67	69	68
08/09/79	600	20500	153	153	1.35	1.26	3.00	3.00	14.40	14.40	47	60	4.00	4.00	59	84
08/10/79	500	21590	153	153	1.44	1.33	3.00	3.00	14.10	13.60	49	60	4.00	4.00	-	-
08/11/79	2200	22080	145	145	1.63	1.51	3.00	3.00	17.00	10.40	55	57	4.00	4.00	110	128
08/12/79	1200	22150	158	158	1.51	1.28	3.00	3.00	13.40	14.40	53	56	4.00	4.00	106	87
08/13/79	1800	23010	129	129	1.46	1.29	3.00	3.00	13.40	13.70	47	58	4.00	4.00	104	148
08/14/79	100				1.56	1.36	3.00	3.00	13.70	15.40	52	60	4.00	4.00	89	126
	900				1.55	1.38	3.00	3.00	13.90	14.90	53	60	4.00	4.00	95	58
					1.49	1.42	3.00	3.00	14.90	15.80	58	55	4.00	4.00	117	120
					1.57	1.48	3.10	3.10	15.80	15.30	50	58	4.00	4.00	3280	92
					1.71	1.52	3.10	3.10	14.50	15.40	50	58	4.00	4.00	-	-
					1.61	1.44	3.20	3.20	16.20	16.00	48	58	4.00	4.00	-	-
					1.67	1.52	3.20	3.20	16.40	16.50	52	57	4.00	4.00	-	-
					1.61	1.43	3.30	3.30	16.30	16.00	51	56	4.00	4.00	-	-
					1.45	1.44	3.50	3.50	15.30	15.00	55	59	4.00	4.00	-	-
					1.62	1.52	3.50	3.50	16.00	15.00	52	60	4.00	4.00	-	-
					1.51	1.63	3.50	3.50	15.40	14.70	50	58	4.00	4.00	-	-
					1.61	1.56	3.60	3.60	15.20	14.80	50	62	4.00	4.00	-	-

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TABLE D (continued)

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	Fec13 DOSE lb/ton	FILTER YIELD based on cake solids TF BF	SLUDGE pH TF BF	CAKE SOLIDS TF BF %	FORM TIME sec TF BF	CYCLE TIME min TF BF	FILTRATE SUSPENDED SOLIDS mg/l TF BF
08/15/79	1700	20190	134	1.69 1.64	3.70 3.70	15.20 15.40	53 50	4.00 4.00	76
	800		134	1.64 1.54	3.70 3.70	15.10 14.80	59 55	4.00 4.00	134
08/16/79	1600			1.66 1.45	3.70 3.70	14.90 15.00	51 60	4.00 4.00	
	2300			1.41 1.39	3.80 3.80	15.40 15.60	42 45	4.00 4.00	
08/17/79	900	18690	130	1.65 1.25	3.80 3.70	17.00 15.20	44 39	4.00 4.00	
	1500			1.52 1.40	3.70 3.70	15.10 15.50	45 50	4.00 4.00	250
	2200			1.32 1.18	3.70 3.70	15.10 15.40	42 38	4.00 4.00	
08/17/79	400	17530	140	1.24 1.15	3.70 3.70	14.80 14.90	44 40	4.00 4.00	
	1400			1.39 1.11	3.70 3.70	13.60 15.30	43 40	4.00 4.00	120
08/18/79	2100			1.13 1.10	3.60 3.60	15.00 14.20	45 45	4.00 4.00	170
	500	16200	141	1.21 1.17	3.60 3.60	15.60 15.00	41 46	4.00 4.00	
08/19/79	1300			1.35 1.13	3.40 3.40	14.80 15.60	43 37	4.00 4.00	
	2000			1.20 1.09	3.40 3.40	14.50 15.40	39 38	4.00 4.00	59
08/19/79	400	15800	150	1.25 1.07	3.40 3.40	14.90 15.40	41 39	4.00 4.00	
	1200			1.13 1.03	3.40 3.40	13.40 15.60	43 39	4.00 4.00	62
08/20/79	1900			1.18 1.02	3.40 3.40	15.20 15.30	41 40	4.00 4.00	52
	300	18030	122	1.28 0.96	3.40 3.40	15.70 15.70	45 45	4.00 4.00	50
08/20/79	1100			1.33 1.03	3.40 3.40	16.40 16.90	43 41	4.00 4.00	
	2300			1.01 0.99	3.40 3.40	16.10 16.10	37 40	4.00 4.00	
08/21/79	2200	18200	144	1.32 1.17	3.40 3.40	15.10 15.60	45 42	4.00 4.00	56
08/22/79	500	19300	135	1.29 1.16	3.50 3.60	16.70 15.70	40 45	4.00 4.00	128
	1300			1.35 1.25	3.60 3.60	15.90 16.40	43 41	4.00 4.00	52
08/23/79	2000			1.35 1.25	3.40 3.40	16.40 16.90	43 41	4.00 4.00	50
	300	19700	136	1.56 1.31	3.40 3.40	16.30 16.30	37 40	4.00 4.00	
08/23/79	1100			1.31 1.25	3.40 3.40	15.10 15.60	45 42	4.00 4.00	56
08/24/79	1800			1.24 1.16	3.40 3.40	16.10 16.90	34 40	4.00 4.00	
	100	19900	136	1.33 1.30	3.40 3.40	15.90 15.20	34 40	4.00 4.00	71
08/25/79	900			1.31 1.22	3.40 3.40	16.10 16.30	38 38	4.00 4.00	
	1700	20000	141	1.27 1.28	3.40 3.40	14.50 15.30	36 35	4.00 4.00	
	800			1.28 1.23	3.40 3.40	16.00 15.10	35 40	4.00 4.00	98
08/26/79	1600			1.23 1.16	3.40 3.40	16.40 14.90	36 43	4.00 4.00	
	2300			1.54 1.32	3.40 3.40	15.60 14.20	38 38	4.00 4.00	
08/26/79	1400	20300	132	1.36 1.29	3.20 3.20	15.40 15.30	34 48	3.67 3.67	61
	2100			1.24 1.33	3.20 3.20	15.80 14.40	35 43	3.67 3.67	
09/01/79	1030	19340	174	1.18 1.21	3.20 3.20	16.60 17.80	35 43	3.67 3.67	100
	1500			1.71 1.26	3.20 3.20	14.50 14.60	40 42	3.67 3.67	
09/02/79	1700			1.26 1.09	3.20 3.20	15.40 14.20	40 45	3.67 3.67	70
	800	18990	204	1.34 1.16	3.50 3.50	14.70 14.70	37 45	3.67 3.67	
	1600			1.16 1.08	3.50 3.50	15.60 15.60	40 38	3.67 3.67	
09/03/79	2300			1.21 1.17	3.30 3.30	16.70 14.40	40 45	3.67 3.67	74
	600	19990	198	1.22 1.25	3.30 3.30	15.50 14.10	39 45	3.67 3.67	
	1400			1.39 1.29	3.30 3.30	14.70 14.70	45 45	3.67 3.67	
09/04/79	2100			1.15 1.17	3.40 3.50	16.70 13.60	48 45	3.67 3.67	
	400	20250	194	1.26 1.11	3.50 3.50	14.30 15.10	45 45	3.67 3.67	
09/05/79	200	22810	199	1.42 1.14	3.50 3.50	14.20 15.90	49 35	3.67 3.67	
	1800			1.23 1.27	3.60 3.60	15.30 15.30	43 43	3.67 3.67	3231
09/06/79	300	22920	190	1.40 1.53	3.60 3.60	16.20 15.30	36 49	3.67 3.67	262
	700			1.45 1.42	3.60 3.50	15.70 15.40	40 39	3.67 3.67	73
1000					3.50	15.90	45	3.67	

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeCl ₃ DOSE lb/ton TF BF	FILTER YIELD based on cake solids TF BF	SLUDGE pH TF BF	CAKE SOLIDS % TF BF	FORM TIME sec TF BF	CYCLE TIME min TF BF	FILTRATE SUSPENDED SOLIDS mg/l TF BF
09/07/79	1500			1.51 1.45	3.50 3.50	15.60 15.00	36 45	3.67 3.67	
	2200	23000	251 251	1.45 1.46	3.50 3.50	15.60 14.90	45 45	3.67 3.67	
	500			1.81 1.52	3.50 3.50	13.70 14.70	46 47	3.67 3.67	94 98
09/08/79	1800			1.47 1.41	3.50 3.50	15.40 15.30	43 45	3.67 3.67	
	2200	22130	157 157	1.46 1.45	3.50 3.50	15.40 14.50	40 45	3.67 3.67	
	300			1.43 1.48	3.50 3.50	15.60 13.90	38 45	3.67 3.67	176 171
	1100			1.34 1.33	3.50 3.50	15.60 13.90	37 45	3.67 3.67	
09/09/79	1800	21040	173 173	1.36 1.35	3.50 3.50	15.20 13.90	40 45	3.67 3.67	
	100			1.33 1.74	3.50 3.50	15.50 15.10	33 32	3.67 3.67	188 180
	930			1.32 1.35	3.50 3.50	15.40 13.70	35 47	3.67 3.67	
09/10/79	1700	21580	168 168	2.20 1.61	3.50 3.50	20.50 15.30	44 55	3.67 3.67	
	800			2.48 1.63	3.50 3.50	21.60 15.90	42 53	3.67 3.67	124 112
09/11/79	1800	21000	177 177	1.63 2.46	3.50 3.50	19.40 23.40	41 58	3.67 3.67	
	600			2.10 2.10	3.50 3.50	24.70 23.50	40 55	3.67 3.67	98 106
09/12/79	2100	19045	185 185	1.41 1.31	3.50 3.50	14.00 13.50	46 55	3.67 3.67	
	400			1.41 1.39	3.50 3.50	14.90 14.40	40 53	3.67 3.67	98 124
09/13/79	1200	20260	195 195	1.36 1.26	3.50 3.50	14.20 13.50	47 55	3.67 3.67	
	1900			1.39 1.28	3.50 3.50	13.50 13.50	46 53	3.67 3.67	
	400			1.23 1.23	3.52 3.52	15.50 14.40	39 52	3.67 3.67	116 106
09/14/79	1000	19370	188 188	1.32 1.22	3.50 3.50	14.10 13.20	44 55	3.67 3.67	
	1800			1.34 1.27	3.50 3.50	12.50 12.10	43 58	3.67 3.67	
	300			1.33 1.26	3.40 3.40	13.90 12.90	44 55	3.67 3.67	158 133
09/15/79	1600	20020	209 209	1.17 1.37	3.30 3.30	13.20 14.50	40 54	3.67 3.67	
	2000			1.34 1.29	3.30 3.30	13.20 13.20	43 55	3.67 3.67	
	500			1.43 1.28	3.40 3.40	13.10 13.20	44 53	3.67 3.67	159 159
09/16/79	1100	20070	188 188	1.46 1.31	3.40 3.40	13.30 13.50	43 55	3.67 3.67	
	2000	21329	191 191	1.48 1.37	3.40 3.40	13.30 13.30	40 55	3.67 3.67	
09/17/79	300			1.44 1.35	3.40 3.40	13.50 13.30	42 54	3.67 3.67	150 108
	1330			1.34 1.30	3.30 3.30	14.60 14.00	42 57	3.67 3.67	95 110
09/18/79	1700	20922	170 170	1.30 1.31	3.30 3.30	14.00 12.80	45 56	3.67 3.67	
	100			1.42 1.37	3.30 3.30	13.30 13.60	45 54	3.67 3.67	160 82
09/19/79	900	21210	171 171	1.41 1.42	3.30 3.30	13.00 13.30	45 58	3.67 3.67	
	1700			1.38 1.38	3.30 3.30	14.60 13.60	43 57	3.67 3.67	
	800			1.31 1.34	3.30 3.30	15.10 14.00	37 54	3.67 3.67	112 112
09/20/79	1600	21180	172 172	1.33 1.27	3.30 3.30	13.10 14.10	42 55	3.67 3.67	
	2300			1.40 1.42	3.30 3.30	14.30 13.50	42 53	3.67 3.67	
	700			1.45 1.41	3.20 3.20	13.60 14.10	41 55	3.67 3.67	183 110
09/21/79	1800	20450	206 206	1.29 1.22	3.10 3.10	15.30 14.20	34 45	3.67 3.67	
	2200			1.22 1.18	3.20 3.20	15.00 14.60	33 43	3.67 3.67	
	600			1.23 1.22	3.10 3.10	14.50 14.50	37 45	3.67 3.67	120 120
09/22/79	1400	20870	189 189	1.25 1.28	3.10 3.10	15.10 13.90	35 48	3.67 3.67	
	2100			1.19 1.29	3.10 3.10	14.40 14.10	37 45	3.67 3.67	
	600			1.12 1.14	3.10 3.10	14.60 14.40	38 47	3.67 3.67	236 125
09/23/79	1300	21940	198 198	1.21 1.50	3.10 3.10	10.60 11.40	37 48	3.67 3.67	
	2000			1.29 1.33	3.10 3.10	15.50 14.40	35 47	3.67 3.67	
	400			1.40 1.36	3.10 3.10	13.70 14.00	37 54	3.67 3.67	143 190
09/24/79	1200	21760	205 205	1.32 1.19	3.10 3.10	14.00 14.80	34 48	3.67 3.67	
	1900			1.41 1.30	3.10 3.10	13.10 14.10	30 58	3.67 3.67	
	300			1.35 1.34	3.10 3.10	14.60 13.30	40 68	3.67 3.67	121 136

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FEC13 DOSE lb/ton	FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec		CYCLE TIME min		FILTRATE SUSPENDED SOLIDS mg/l	
				TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
02/19/80	100	13600	88	1.54	1.44	3.60	3.60	14.89	14.91	45	60	4.00	4.00	41	35
	900			1.36	1.28	3.60	3.60	15.18	15.01	40	59	4.00	4.00		
	1700			1.48	1.40	3.60	3.60	15.16	15.16	55	60	4.00	4.00		
02/20/80	800	14100	80	1.58	1.42	3.60	3.60	15.07	15.41	52	58	4.00	4.00	42	26
	1600			1.38	1.31	3.60	3.60	14.89	14.91	48	56	4.00	4.00		
02/21/80	2230	13700	83	1.29	1.35	3.60	3.60	14.65	16.28	46	56	4.00	4.00		
02/22/80	0	13400	73	1.34	1.35	3.60	3.60	13.05	15.36	47	60	4.00	4.00	99	80
	200			1.35	1.31	3.60	3.60	13.04	14.62	40	61	4.00	4.00	99	97
	400			1.23	1.33	3.60	3.60	14.58	14.58	43	60	4.00	4.00		
	600			1.30	1.30	3.60	3.60	15.32	15.26	44	57	4.00	4.00		
	1630			1.40	1.36	3.60	3.60	15.69	15.12	44	60	4.00	4.00		
	2100			1.33	1.39	3.60	3.60	15.72	15.14	44	59	4.00	4.00		
	1300			1.37	1.28	3.60	3.60	15.43	15.65	45	50	4.00	4.00		
02/23/80	500	14200	76	1.70	1.51	3.50	3.50	17.71	17.78	43	50	4.00	4.00	105	84
	1300			1.58	1.40	3.50	3.50	15.25	15.44	44	50	4.00	4.00		
	2000			1.50	1.39	3.50	3.50	14.91	16.30	45	50	4.00	4.00		
02/24/80	400	14800	78	1.70	1.40	3.50	3.50	15.06	15.98	45	50	4.00	4.00	79	28
	1200			1.82	1.40	3.50	3.50	16.43	15.93	44	49	4.00	4.00		
	1700			1.76	1.35	3.50	3.50	15.13	14.42	48	51	4.00	4.00		
02/25/80	300	14200	74	1.72	1.47	3.50	3.50	14.47	15.74	46	50	4.00	4.00	57	20
	1100			1.64	1.51	3.60	3.60	15.30	15.09	46	50	4.00	4.00		
	1800			1.55	1.20	3.70	3.70	15.84	13.75	45	48	4.00	4.00		
02/26/80	200	12900	92	1.63	1.40	3.70	3.70	15.49	15.78	45	48	4.00	4.00	69	69
02/27/80	1200	15000	78	1.40	1.22	3.70	3.70	14.91	15.83	47	50	4.00	4.00	57	130
	1700			1.44	1.29	3.60	3.60	15.57	15.33	35	40	4.00	4.00		
	2000			1.39	1.21	3.50	3.50	15.62	15.58	36	40	4.00	4.00		
02/28/80	800	14700	77	1.32	1.22	3.50	3.50	15.43	15.26	38	38	4.00	4.00	88	44
	1200			1.35	1.17	3.50	3.50	15.45	16.03	36	40	4.00	4.00		
02/29/80	1500	14095	83	1.29	1.13	3.40	3.40	14.00	14.60	45	40	4.00	4.00	183	89
	2200			1.43	1.20	3.30	3.30	14.80	15.00	35	40	4.00	4.00		
03/01/80	300	13985	86	1.30	1.33	3.30	3.30	15.20	14.60	37	40	4.00	4.00	89	37
	600			1.49	1.32	3.30	3.30	15.20	15.20	36	39	4.00	4.00		
	830			1.35	1.32	3.30	3.30	14.90	13.10	35	42	4.00	4.00		
03/02/80	2100	14112	79	1.44	1.30	3.30	3.30	14.80	15.20	36	40	4.00	4.00	46	37
	1300			1.45	1.40	3.30	3.30	15.00	14.70	38	38	4.00	4.00		
	1800			1.29	1.18	3.40	3.40	15.70	15.00	38	35	4.00	4.00		
03/03/80	400	13300	93	1.37	1.34	3.40	3.40	14.40	14.20	42	50	4.00	4.00	68	30
	1200			1.44	1.35	3.40	3.40	13.60	13.70	45	49	4.00	4.00		
	1900			1.57	1.29	3.40	3.40	14.90	14.20	45	50	4.00	4.00		
03/04/80	900	14358	85	1.55	1.31	3.40	3.40	13.20	14.30	46	49	4.00	4.00	66	40
	1700			1.30	1.07	3.40	3.40	13.40	13.40	45	48	4.00	4.00		
03/05/80	800	14940	77	1.69	1.25	3.50	3.50	13.50	15.00	53	40	4.00	4.00	124	55
	1600			1.68	1.19	3.50	3.50	13.10	15.60	50	38	4.00	4.00		
	2300			1.13	1.13	3.50	3.50	13.90	15.50	36	37	4.00	4.00		
03/06/80	700	14400	79	1.45	1.28	3.50	3.50	14.60	15.10	42	50	4.00	4.00	99	79
				1.57	1.35	3.50	3.50	14.00	14.40	45	50	4.00	4.00		
				1.48	1.27	3.50	3.50	13.70	14.50	46	50	4.00	4.00		
				1.42	1.30	3.50	3.50	13.90	14.00	50	60	4.00	4.00		
				1.58	1.38	3.50	3.50	12.90	13.30	55	72	4.00	4.00		
				1.50	1.34	3.50	3.50	13.60	14.10	50	66	4.00	4.00		
				1.30	1.41	3.50	3.50	13.90	13.40	50	76	4.00	4.00		

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeCl3 DOSE lb/ton		FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec		CYCLE TIME min		FILTRATE SUSPENDED SOLIDS mg/l	
			TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
03/08/80	2200	13600	94	94	1.41	1.22	3.40	3.40	12.76	13.18	50	70	4.00	4.00	271	94
03/09/80	100	13700	94	94	1.48	1.18	3.40	3.40	14.69	14.19	50	54	4.00	4.00	104	32
	400				1.39	1.16	3.40	3.40	12.93	14.12	48	52	4.00	4.00		
	1200				1.45	1.33	3.40	3.40	13.75	15.06	52	50	4.00	4.00		
03/10/80	1700	13500	93	93	1.60	1.30	3.40	3.40	13.13	13.91	52	52	4.00	4.00	82	30
	300				1.44	1.25	3.40	3.40	14.10	15.14	54	58	4.00	4.00		
	1100				1.48	1.32	3.40	3.40	12.95	13.53	54	67	4.00	4.00		
03/11/80	1800	13600	90	90	1.52	1.31	3.40	3.40	13.45	14.14	51	66	4.00	4.00	89	30
	200				1.38	1.27	3.40	3.40	13.69	13.97	52	69	4.00	4.00		
	1000				1.24	1.25	3.40	3.40	13.89	13.82	56	70	4.00	4.00		
03/12/80	1800	13600	92	92	1.36	1.25	3.40	3.40	13.71	13.37	56	74	4.00	4.00	102	27
	400				1.14	.99	3.40	3.40	15.43	15.77	35	39	4.00	4.00		
	1100				1.29	1.32	3.40	3.40	14.10	20.74	49	37	4.00	4.00		
	1800				1.35	.98	3.40	3.40	13.86	16.76	53	36	4.00	4.00		
03/13/80	100	13700	94	94	1.45	.91	3.40	3.40	15.29	13.76	55	35	4.00	4.00	96	108
	900				1.37	1.22	3.40	3.40	19.47	18.01	40	40	4.00	4.00		
03/14/80	200	15500	82	82	1.34	1.18	3.40	3.40	16.95	17.09	37	39	4.00	4.00	102	39
	400				1.24	1.27	3.40	3.40	17.76	18.11	37	38	4.00	4.00		
	1800				1.41	1.11	3.40	3.40	14.71	15.53	42	37	4.00	4.00		
03/15/80	2200	14000	88	88	1.39	1.12	3.40	3.40	14.22	15.24	45	36	4.00	4.00		
	800				1.30	1.11	3.40	3.40	14.78	15.23	40	36	4.00	4.00	79	48
	2300				1.50	1.14	3.40	3.40	12.56	14.56	40	39	4.00	4.00		
03/16/80	600	15100	88	88	1.28	1.22	3.40	3.40	14.30	14.44	43	47	4.00	4.00	86	40
	1500				1.46	1.13	3.40	3.40	13.52	14.82	49	43	4.00	4.00		
	2100				1.45	1.28	3.40	3.40	14.50	14.70	43	50	4.00	4.00		
03/17/80	500	15200	79	79	1.33	1.31	3.30	3.30	15.89	15.40	43	45	4.00	4.00	63	45
	700	16920	87	87	1.31	1.17	3.30	3.30	15.92	15.54	36	38	4.00	4.00	78	87
03/18/80	1500				1.31	1.15	3.30	3.30	19.50	16.90	32	34	4.00	4.00		
	2200				1.30	1.08	3.30	3.30	15.60	16.00	40	27	4.00	4.00		
03/19/80	400	14200	117	117	1.35	1.19	3.30	3.30	15.50	16.20	40	38	4.00	4.00	74	55
	1200				1.64	1.44	3.00	3.00	15.50	16.20	39	42	4.00	4.00		
	1900				1.69	1.45	3.30	3.30	15.40	15.90	44	35	4.00	4.00		
03/20/80	100	11000	139	139	1.89	1.62	3.30	3.30	15.40	15.80	45	50	4.00	4.00	63	53
	900				1.83	1.70	3.30	3.30	15.50	15.70	46	49	4.00	4.00		
	1700				1.94	1.69	3.30	3.30	14.00	15.30	50	60	4.00	4.00		
03/21/80	800	15500	95	95	1.57	1.30	3.30	3.30	14.61	14.68	50	50	4.00	4.00	65	90
	1600				1.61	1.44	3.30	3.30	13.85	14.77	50	55	4.00	4.00		
	2300				1.53	1.32	3.30	3.30	12.84	13.23	55	65	4.00	4.00		
03/22/80	700	15700	93	93	1.36	1.35	3.30	3.30	13.96	13.70	55	67	4.00	4.00	51	37
	1500				1.71	1.42	3.30	3.30	13.01	14.04	55	65	4.00	4.00		
	2200				1.62	1.34	3.30	3.30	13.47	14.65	54	52	4.00	4.00		
03/23/80	600	15700	96	96	1.57	1.41	3.20	3.20	13.13	13.72	55	58	4.00	4.00	60	29
	1400				1.56	1.34	3.20	3.20	13.34	14.20	54	59	4.00	4.00		
	2100				1.49	1.20	3.20	3.20	14.25	15.11	47	44	4.00	4.00		
03/24/80	500	15500	101	101	1.65	1.35	3.20	3.20	13.81	11.11	49	50	4.00	4.00	86	37
	1300				1.59	1.47	3.30	3.30	13.46	13.33	54	50	4.00	4.00		
	2000				1.56	1.34	3.30	3.30	14.20	14.78	53	50	4.00	4.00		
03/25/80	400	17000	85	85	1.48	1.27	3.30	3.30	14.29	15.31	52	47	4.00	4.00	68	105
	1900				1.56	1.33	3.40	3.40	14.56	15.37	50	54	4.00	4.00		
	300	15450	103	103	1.59	1.43	3.40	3.40	14.80	15.00	50	51	4.00	4.00		
					1.60	1.42	3.50	3.50	14.10	14.50	54	64	4.00	4.00		
03/26/80					1.58	1.58	3.50	3.50	14.10	14.60	55	70	4.00	4.00	60	53

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeCl3 DOSE lb/ton	FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec	CYCLE TIME min		FILTRATE SUSPENDED SOLIDS mg/l
				TF	BF	TF	BF	TF	BF		TF	BF	
03/27/80	1100			1.35	1.25	3.50	3.50	12.10	12.40	54	59	4.00	4.00
	1800			1.38	1.29	3.40	3.40	12.80	13.40	50	46	4.00	4.00
	200			1.43	1.32	3.40	3.40	12.60	12.80	47	50	4.00	4.00
03/28/80	800			1.50	1.44	3.40	3.40	13.80	14.30	45	50	4.00	4.00
	2100		180	1.38	1.50	3.40	3.50	12.60	14.70	75	50	4.67	4.00
03/29/80	300		136	1.31	1.63	3.40	3.40	11.90	13.00	68	62	4.75	4.00
	800			1.38	1.63	3.40	3.40	12.00	13.50	68	60	4.67	4.00
	1600			1.19	1.40	3.40	3.20	11.70	14.90	70	55	4.75	4.00
03/30/80	2300			1.43	1.62	3.40	3.40	11.70	13.50	70	56	4.67	4.00
	700			1.36	1.05	3.40	3.50	11.40	9.40	70	54	4.67	4.00
	1500		148	1.34	1.57	3.40	3.60	12.90	13.40	64	55	4.25	4.00
03/31/80	2000			1.53	2.14	3.40	3.70	14.10	17.50	70	62	4.25	4.00
	600			1.36	1.45	3.40	3.40	13.00	12.40	67	57	4.25	4.00
	1400		142	1.43	1.65	3.40	3.50	13.30	13.70	66	62	4.20	4.00
04/01/80	2100			1.38	1.60	3.40	3.40	12.50	14.10	69	60	4.80	4.00
	300		182	1.40	1.73	3.40	3.40	13.40	13.90	67	55	4.80	4.00
	1000	122		1.49	1.59	3.40	3.50	13.70	14.90	70	60	4.80	4.00
04/03/80	2230			1.47	1.90	3.40	4.60	12.10	14.10	69	60	4.80	4.00
	300		114	1.22	1.74	3.90	3.90	12.70	14.60	37	58	4.00	4.00
04/04/80	600			1.64	1.47	3.70	3.70	13.70	13.30	33	63	4.00	4.00
	1400			1.15	1.56	3.70	3.60	12.60	13.80	52	36	4.00	4.00
	1800		115	1.27	1.66	3.30	3.60	13.60	12.80	56	60	4.00	4.00
04/05/80	2200			1.54	1.63	3.30	3.50	13.70	15.50	80	60	5.00	4.00
	300		123	1.52	1.62	3.30	3.80	13.80	14.90	70	51	4.80	4.00
	1300			1.54	1.78	3.30	3.90	13.70	14.40	75	65	4.80	4.00
04/06/80	2000			1.28	1.66	3.30	3.80	11.40	14.60	74	62	4.80	4.00
	700		48	1.51	1.72	3.30	3.80	14.60	14.40	70	60	4.80	4.00
	1500			1.62	1.52	3.70	3.40	15.20	14.30	38	70	4.00	4.80
04/07/80	200			1.45	1.55	3.70	3.40	15.30	14.10	40	71	4.00	4.80
	600			1.57	1.61	3.60	3.40	15.10	14.40	38	71	4.00	4.80
	1100			1.67	1.59	3.80	3.40	13.50	14.90	51	69	4.00	4.80
04/08/80	1900			1.78	1.58	3.70	3.50	15.10	15.50	50	69	4.00	4.80
	300		93	1.82	1.70	3.80	3.50	15.00	15.30	50	70	4.00	4.80
	900			1.71	1.64	3.90	3.50	14.60	14.90	49	70	4.00	4.80
04/09/80	2400			1.73	1.31	3.50	3.50	16.80	15.80	39	90	4.00	6.80
	800		82	1.59	1.68	3.50	3.50	15.20	14.30	43	65	4.00	4.50
	1600			1.78	1.71	3.70	3.50	14.20	14.70	45	67	4.00	4.30
04/10/80	700			1.77	1.64	3.60	3.50	14.00	14.80	45	66	4.00	4.30
	1500		100	1.75	1.50	3.70	3.50	12.60	14.80	45	70	4.00	4.30
	600			1.95	1.65	3.60	3.40	13.80	14.60	38	63	4.00	4.30
04/11/80	1400		108	1.97	1.55	3.80	3.40	14.30	14.80	38	62	4.00	4.30
	2100			1.93	1.49	3.80	3.40	14.40	17.60	37	63	4.00	6.30
	500		112	1.55	1.82	3.80	3.40	15.70	16.40	36	64	4.00	4.30
04/12/80	1300			1.92	1.72	3.80	3.40	14.20	13.80	37	65	4.00	4.30
	2200			1.14	1.62	3.80	3.40	10.10	14.50	35	70	4.00	4.30
	500		108	2.29	1.99	3.80	3.14	16.90	16.20	36	65	4.00	4.30
04/13/80	1200			1.92	1.56	3.80	3.14	14.90	14.60	38	64	4.00	4.30
	1900			1.94	1.65	3.80	3.14	14.80	14.00	37	64	4.00	4.30
	300		107	1.99	1.80	3.80	3.40	15.10	14.30	38	65	4.00	4.30
04/14/80	1100			1.91	1.84	3.80	3.40	14.90	14.20	38	64	4.00	4.30
	1800			2.04	1.67	3.70	3.40	15.00	14.60	36	64	4.00	4.30

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeCl ₃ DOSE lb/ton		FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec		CYCLE TIME min		FILL RATE SUSPENDED SOLIDS mg/l	
			TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
04/16/80	200	16820	127	-	1.90	1.82	3.80	3.40	15.50	14.20	37	64	4.00	4.30	92	-
04/17/80	1000	17680	120	-	2.16	1.77	3.50	3.40	14.70	14.20	38	64	4.00	4.30	83	-
04/18/80	1800	17680	121	-	2.11	1.77	3.80	3.40	14.80	13.20	37	80	4.00	5.00	83	-
04/20/80	100	16760	121	-	2.22	1.86	3.50	3.40	13.60	12.60	36	80	4.00	5.00	83	-
04/21/80	900	16760	121	-	2.17	1.74	3.60	3.40	13.50	12.90	38	80	4.00	5.00	83	-
04/22/80	1700	16760	121	-	2.19	1.48	3.60	3.40	13.70	13.00	38	73	4.00	5.00	83	-
04/23/80	800	16760	121	-	2.05	1.39	3.50	3.30	14.20	14.70	36	74	4.00	5.00	83	-
04/24/80	1600	16760	121	-	1.74	1.94	3.60	3.30	14.50	14.10	33	75	4.00	5.00	83	-
04/25/80	2300	16760	121	-	1.81	1.79	3.50	3.30	14.70	15.50	32	31	4.00	4.00	152	75
04/26/80	600	16760	121	-	1.63	1.11	3.40	3.70	14.90	19.50	32	39	4.00	4.00	-	-
04/27/80	2000	16760	121	-	1.48	1.39	3.60	3.60	15.30	15.00	35	39	4.00	4.00	61	52
04/28/80	100	16760	121	-	1.55	1.25	3.80	3.60	15.60	16.10	36	35	4.00	4.00	54	44
04/29/80	2100	16760	121	-	1.76	1.30	3.40	3.60	16.20	15.70	39	50	4.00	4.00	81	45
04/30/80	200	16760	121	-	1.48	1.38	3.60	3.60	14.80	15.30	38	50	4.00	4.00	122	68
04/31/80	1000	16760	121	-	1.43	1.36	3.70	3.40	14.40	15.20	38	50	4.00	4.00	84	79
05/01/80	1800	16760	121	-	1.60	1.43	3.70	3.40	14.60	18.30	38	50	4.00	4.00	76	70
05/02/80	800	16760	121	-	1.89	1.47	3.40	3.60	11.90	15.80	40	50	4.00	4.00	66	51
05/03/80	2200	16760	121	-	1.43	1.13	3.60	3.60	13.20	15.20	40	50	4.00	4.00	-	-
05/04/80	600	16760	121	-	1.51	1.39	3.60	3.40	14.40	14.10	41	60	4.00	4.00	122	68
05/05/80	2100	16760	121	-	1.36	1.18	4.20	3.40	13.20	15.20	40	50	4.00	4.00	84	79
05/06/80	500	16760	121	-	1.50	1.36	4.00	3.60	13.80	15.00	35	53	4.00	4.00	76	70
05/07/80	1300	16760	121	-	1.53	1.23	3.50	3.60	13.80	14.90	40	55	4.00	4.00	66	51
05/08/80	2000	16760	121	-	1.86	1.23	3.50	3.60	12.90	13.70	40	54	4.00	4.00	-	-
05/09/80	1500	16760	121	-	2.63	1.07	3.30	3.60	18.50	16.30	45	30	4.00	4.00	122	68
05/10/80	400	16760	121	-	1.78	1.48	3.80	3.50	13.50	14.80	43	53	4.00	4.00	84	79
05/11/80	1200	16760	121	-	2.02	1.31	3.70	3.80	14.00	13.10	40	55	4.00	4.00	76	70
05/12/80	2200	16760	121	-	1.82	1.53	3.60	3.00	13.80	14.90	45	55	4.00	4.00	66	51
05/13/80	1300	16760	121	-	1.94	1.53	3.70	3.80	13.00	14.50	48	62	4.00	4.00	-	-
05/14/80	2000	16760	121	-	2.16	1.66	3.20	3.20	15.60	15.70	32	50	4.00	4.00	122	68
05/15/80	1400	16760	121	-	1.83	1.60	3.40	3.20	14.50	14.90	40	52	4.00	4.00	84	79
05/16/80	1300	16760	121	-	2.20	1.77	4.00	3.20	12.60	14.00	43	59	4.00	4.00	76	70
05/17/80	2000	16760	121	-	1.98	1.52	3.10	3.10	13.50	16.20	45	52	4.00	4.00	66	51
05/18/80	1300	16760	121	-	1.93	1.63	3.10	3.10	12.90	13.80	48	53	4.00	4.00	-	-
05/19/80	1700	16760	121	-	1.65	1.48	3.00	3.00	14.50	14.20	38	51	4.00	4.00	286	77
05/20/80	2100	16760	121	-	1.61	1.47	3.00	3.00	14.20	14.20	42	56	4.00	4.00	101	82
05/21/80	300	16760	121	-	1.44	1.44	3.00	3.00	13.80	14.40	45	53	4.00	4.00	164	77
05/22/80	1500	16760	121	-	1.76	1.43	2.90	2.90	12.40	13.70	47	52	4.00	4.00	164	77
05/23/80	300	16760	121	-	1.62	1.34	3.10	3.10	13.90	15.70	44	58	4.00	4.00	113	63
05/24/80	900	16760	121	-	1.57	1.40	3.10	3.10	15.70	15.70	47	63	4.00	4.00	129	53
05/25/80	300	16760	121	-	1.37	1.37	3.10	3.10	15.50	15.50	47	62	4.00	4.00	163	45
05/26/80	800	16760	121	-	1.66	1.60	3.10	3.10	15.90	15.12	44	73	4.00	4.00	95	95
05/27/80	1800	16760	121	-	1.64	1.57	3.10	3.10	16.12	15.18	47	74	4.00	4.00	164	77
05/28/80	100	16760	121	-	1.65	1.58	3.10	3.10	15.60	15.00	43	75	4.00	4.00	113	63
05/29/80	2200	16760	121	-	1.84	1.77	3.20	3.20	16.80	13.90	48	74	4.00	4.00	129	53
05/30/80	600	16760	121	-	1.70	1.65	3.20	3.20	15.10	14.20	51	74	4.00	4.00	163	45
05/31/80	300	16760	121	-	1.56	1.62	3.20	3.20	15.80	14.60	57	76	4.00	4.00	266	95
06/01/80	1100	16760	121	-	1.56	1.46	3.30	3.30	15.80	16.10	45	56	4.00	4.00	164	77
06/02/80	1800	16760	121	-	1.50	1.34	3.30	3.30	15.50	16.20	44	52	4.00	4.00	197	62
06/03/80	1800	16760	121	-	1.38	1.48	3.30	3.30	15.70	14.90	45	55	4.00	4.00	164	77

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeC13 DOSE lb/ton		FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec		CYCLE TIME min		FILTRATE SUSPENDED SOLIDS mg/l	
			TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
05/18/80	100	18150	126	126	1.43	1.39	3.30	3.30	15.20	15.20	46	67	4.00	4.00	138	53
	900				1.60	1.39	3.30	3.30	14.40	15.90	52	60	4.00	4.00		
05/19/80	1700				1.49	1.37	3.30	3.30	15.80	16.20	48	47	4.00	4.00		
05/20/80	200	18350	-	-	1.53	1.51	3.30	3.30	16.40	16.10	43	52	4.00	4.00	133	54
	1000				1.53	1.42	3.30	3.30	16.30	16.00	44	53	4.00	4.00		
05/20/80	1800	18730	30	31	1.58	1.62	3.30	3.30	15.50	14.80	45	80	4.00	4.00	86	48
	2300				1.49	1.56	3.30	3.30	15.40	17.40	49	51	4.00	4.00		
05/21/80	600	19085	42	42	1.62	1.58	3.20	4.00	15.90	16.00	48	59	4.00	4.00		
	1700				1.44	1.43	3.50	3.70	16.20	16.80	48	54	4.00	4.00	89	54
05/22/80	2100				1.60	1.79	3.40	3.20	16.20	15.20	46	76	4.00	4.00		
	500	19075	31	51	1.77	1.79	3.50	3.20	14.90	15.10	53	79	4.00	4.00		
	1400				1.70	1.74	3.50	3.20	15.20	15.10	48	80	4.00	4.00	169	106
	2000				1.58	1.26	3.50	3.20	15.60	17.60	49	35	4.00	4.00		
05/23/80	700	20790	38	52	1.55	1.43	3.60	3.40	18.50	14.30	47	46	4.00	4.00		
	1300				1.47	1.33	3.40	3.60	16.10	16.60	43	45	4.00	4.00	140	176
05/24/80	400	18965	185	186	1.77	1.26	3.50	3.60	18.10	16.90	44	37	4.00	4.00	128	78
	1200				1.62	1.59	3.30	3.20	14.90	14.40	35	61	4.00	4.00		
05/25/80	1900				1.68	1.67	3.20	3.20	12.30	14.60	42	65	4.00	4.00		
05/26/80	1100	23490	151	227	2.04	1.75	3.10	3.10	13.70	15.00	47	53	4.00	4.00		
	1720	19370	179	209	1.59	1.46	3.60	3.20	16.10	15.90	32	37	4.00	4.00	128	616
	1930				1.51	1.40	3.40	3.10	17.40	16.10	36	55	4.00	4.00	125	51
05/27/80	300	19390	168	202	1.27	1.47	3.50	3.20	14.70	16.40	37	57	4.00	4.00	109	63
	1000				1.20	1.45	3.80	3.00	15.80	16.40	24	64	4.00	4.00		
05/29/80	1800				1.64	1.40	3.60	3.50	15.90	16.50	50	55	4.00	4.00		
05/30/80	2200	27715	199	228	1.66	1.64	3.70	3.70	16.60	15.10	45	72	4.00	4.00	80	76
	300	24000	196	232	2.09	1.90	3.20	3.40	16.80	16.60	46	59	4.00	4.00	108	82
	1300				1.93	1.93	3.20	3.50	16.40	15.00	47	72	4.00	4.00		
05/31/80	100	26200	196	-	2.17	1.52	3.50	3.60	15.20	16.80	50	44	4.00	4.00		
06/01/80	1020	22300	208	-	2.16	2.18	3.30	3.40	15.70	14.30	48	78	4.00	4.00		
	1800				2.31	2.15	3.60	4.00	13.40	14.10	46	74	4.00	4.00	117	-
06/04/80	430	25800	200	237	1.48	1.22	3.50	3.10	16.00	15.50	38	59	4.00	4.00	190	130
	1400				1.79	1.62	3.50	3.50	17.90	15.10	47	61	4.00	4.00		
06/05/80	600	26700	180	294	1.75	1.61	3.00	3.90	17.60	18.10	45	45	4.00	4.00	237	342
	2200				2.04	1.62	3.20	3.00	17.50	16.10	38	68	4.00	4.00		
06/06/80	800	28600	261	132	2.46	1.40	3.50	4.00	16.10	14.60	48	90	4.00	4.00	254	185
	2100				1.95	1.58	3.20	3.60	17.90	16.20	41	50	4.00	4.00		
06/07/80	2200	29700	-	135	2.04	1.62	3.20	3.90	17.40	17.20	43	45	4.00	4.00	218	123
	100	31700	123	123	2.48	1.95	3.50	3.50	17.90	15.10	47	61	4.00	4.00		
06/08/80	800				1.73	1.55	3.30	3.30	18.40	17.20	40	53	4.00	4.00	91	91
	2300	33300	103	103	1.49	1.49	3.20	3.20	17.30	17.30	42	42	4.00	4.00	201	157
06/09/80	400				1.86	1.75	3.20	3.20	19.80	17.70	47	57	4.00	4.00		
	1200	18900	128	128	1.80	1.96	3.20	3.20	17.20	17.60	42	58	4.00	4.00	180	111
06/10/80	1230	16280	87	87	2.23	1.80	3.20	3.20	20.60	18.90	35	55	4.00	4.00		
	1400				2.03	1.91	3.20	3.20	20.60	18.20	39	57	4.00	4.00		
06/12/80	1800				1.58	2.08	3.30	3.30	24.30	21.30	32	50	4.00	4.00		
	2100				1.51	2.05	3.40	3.40	23.30	18.70	30	56	4.00	4.00	-	108
06/13/80	800	13700	94	94	1.61	2.37	3.40	3.40	23.60	27.10	29	62	4.00	4.00	132	83
	1600				1.20	2.34	3.40	3.40	18.80	26.40	31	61	4.00	4.00		
					1.22	1.50	3.40	3.40	18.50	15.50	31	63	4.00	4.00		
					1.18	1.45	3.20	3.20	18.80	15.70	26	60	4.00	4.00	133	49
					1.01	1.17	3.10	3.10	16.40	14.00	30	58	4.00	4.00		
					1.16	1.32	3.10	3.10	17.20	15.00	32	61	4.00	4.00		

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeCl3 DOSE lb/ton	FILTER YIELD based on cake solids	SLUDGE pH	CAKE SOLIDS %	FORM TIME sec	CYCLE TIME min	FILTRATE SUSPENDED SOLIDS mg/l
		TF	BF	TF	BF	TF	TF	BF	TF
06/14/80	2300	18500	93	1.05	3.10	17.00	31	4.00	174
06/15/80	600	13000	136	1.13	3.20	15.70	32	4.00	107
06/16/80	2200	15190	141	1.27	3.20	19.30	32	4.00	168
	100			1.36	3.20	18.70	26	4.00	81
	700			1.18	3.20	19.50	30	4.00	152
06/17/80	1500			1.44	3.20	18.40	34	4.00	
	2200	17700	265	1.49	3.20	18.40	39	4.00	
	200			1.56	3.20	18.60	52	4.00	
06/18/80	2200	17390	168	1.53	3.20	18.80	41	4.00	
	400			1.74	3.50	19.00	50	4.00	132
	1200			1.81	3.50	17.10	37	4.00	
06/19/80	1700			1.76	3.50	16.00	39	4.00	
	500	17570	167	1.89	3.60	17.10	61	4.00	112
	1300			1.84	3.50	16.90	38	4.00	
06/20/80	2000			1.74	3.50	17.30	65	4.00	78
	700	17000	162	1.75	3.60	17.30	35	4.00	
	1100			1.84	3.40	16.50	64	4.00	
	2200			1.83	3.60	16.60	57	4.00	
06/21/80	2200	16945	164	1.80	3.70	16.60	33	4.00	
	200			1.69	3.40	16.80	35	4.00	74
	1500			2.13	3.80	16.20	56	4.00	
06/22/80	2200			1.84	3.50	17.10	37	4.00	
	400	17640	142	1.59	3.70	16.60	55	4.00	75
	1100			1.79	3.80	16.60	34	4.00	
	2100			1.66	3.70	16.50	31	4.00	
06/23/80	100	17395	185	1.56	3.70	18.50	58	4.00	
	900			1.61	3.80	17.40	35	4.00	74
	1700			1.69	3.60	16.70	52	4.00	
06/25/80	1200	21950	180	1.67	3.80	18.90	38	4.00	
	1900			1.74	4.00	17.50	30	4.00	64
	400			1.92	3.50	19.40	40	4.00	
06/26/80	1100	21000	165	1.58	3.40	19.70	62	4.00	
	400			1.81	3.70	18.50	40	4.00	138
	1800			2.21	3.40	18.30	45	4.00	
06/27/80	100	19130	159	2.47	3.60	18.10	39	4.00	
	1000			2.46	3.80	18.10	41	4.00	99
	1700			2.27	3.50	17.80	54	4.00	
06/28/80	200	17500	158	2.14	3.60	17.80	47	4.00	
	1000			1.60	3.80	17.10	51	4.00	73
	1800			1.74	3.50	17.30	53	4.00	
06/29/80	300	19240	125	2.14	3.60	17.10	43	4.00	
	1200			1.67	3.90	18.60	48	4.00	98
	1900			1.44	3.60	18.50	40	4.00	
06/30/80	400	17600	136	2.12	3.80	18.20	44	4.00	
	1200			2.05	3.50	19.10	50	4.00	165
	1300			1.63	3.90	18.40	44	4.00	
07/01/80	500	17900	144	2.14	3.60	18.40	44	4.00	
	1300			1.83	3.80	18.70	55	4.00	108
	2100			1.79	3.60	17.60	49	4.00	
07/02/80	300	18300	153	2.22	3.50	18.20	62	4.00	
	1500			2.11	3.60	18.20	43	4.00	71
	2200			1.83	3.40	17.90	46	4.00	
07/03/80	700	18120	138	2.07	3.70	18.10	60	4.00	
	1400			1.93	3.60	17.40	46	4.00	150
				1.62	3.40	18.35	41	4.00	
				1.71	3.60	18.08	48	4.00	97
				1.69	3.50	19.09	54	4.00	
				1.65	3.60	18.80	40	4.00	87
				1.66	3.50	18.60	40	4.00	
				2.03	3.50	18.20	42	4.00	
				1.74	3.50	17.10	35	4.00	135

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeCl ₃ DOSE lb/ton	FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec		CYCLE TIME min		FILTRATE SUSPENDED SOLIDS mg/l	
				TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
07/04/80	400	17220	170	1.29	1.21	3.40	4.00	17.60	16.90	41	35	4.00	4.00	130	107
07/09/80	600	17370	150	1.40	1.21	3.50	3.80	17.40	16.30	32	26	4.00	4.00	19	4
07/10/80	200	16490	169	1.51	1.43	3.70	3.30	18.80	18.00	45	45	4.00	4.00		
07/11/80	2100	17230	168	1.45	1.37	3.40	3.50	18.20	17.80	34	35	4.00	4.00		
	800			1.56	1.45	3.40	3.40	18.80	18.20	34	35	4.00	4.00	13	10
	1600			1.37	1.45	3.40	3.20	11.75	13.16	34	49	4.00	4.00	122	58
07/12/80	2300		140	1.28	1.36	3.40	3.40	17.10	15.20	37	45	4.00	4.00		
	600	17800		1.35	1.26	3.40	3.40	17.10	16.00	35	58	4.00	4.00		
	1400			1.24	1.26	3.50	3.40	17.30	16.60	35	49	4.00	4.00	129	48
07/13/80	2000	18150	140	1.44	1.43	3.60	3.60	16.40	16.30	38	50	4.00	4.00		
	500			1.34	1.52	3.50	3.50	16.60	16.30	36	68	4.00	4.00		
	1300			1.43	1.43	3.50	3.50	16.20	15.50	35	65	4.00	4.00	22	10
07/14/80	700	14220	187	1.47	1.45	3.60	3.40	18.10	15.40	43	65	4.00	4.00		
07/15/80	1200	17620	126	1.41	1.18	3.40	3.20	15.90	16.30	40	70	4.00	4.00		
	1900			1.47	1.46	3.10	3.80	15.90	14.80	46	68	4.00	4.00	340	53
07/16/80	400	17500	133	1.64	1.75	3.80	4.00	15.30	15.80	46	71	4.00	4.00	279	118
	900			1.64	1.26	3.50	3.80	17.40	13.40	46	65	4.00	4.00	284	124
07/17/80	1700			1.69	1.59	3.60	3.80	14.40	14.40	50	66	4.00	4.00		
	500	18800	118	1.49	1.49	3.80	4.20	14.60	15.30	50	68	4.00	4.00		
	1300			1.56	1.39	3.70	4.20	14.90	16.60	52	53	4.00	4.00	226	77
07/18/80	2000	19000	120	1.67	1.49	3.80	3.80	14.40	16.00	52	52	4.00	4.00		
	700			1.63	1.67	3.60	3.80	15.20	15.90	50	51	4.00	4.00		
07/19/80	1530		157	1.70	1.63	3.70	3.70	13.50	14.50	51	69	4.00	4.00	209	90
	2200	18500		1.62	1.61	3.70	3.90	13.50	14.50	46	71	4.00	4.00		
	1500			1.45	1.49	3.80	3.80	11.00	14.10	47	65	4.00	4.00	362	79
07/22/80	2300	18800	126	1.57	1.61	3.90	3.80	16.20	14.30	37	68	4.00	4.00		
	1500			1.27	1.68	3.70	4.30	17.50	15.20	42	70	4.00	4.00	192	70
07/23/80	400	19900	106	1.54	1.51	3.90	4.30	17.20	15.80	43	70	4.00	4.00		
	1300			1.52	1.60	3.70	3.90	17.40	16.30	43	68	4.00	4.00		
07/24/80	300	19800	142	1.40	1.56	3.80	4.00	17.20	17.00	45	63	4.00	4.00	294	63
	1900			1.40	1.56	3.80	4.00	17.10	16.30	49	65	4.00	4.00		
07/25/80	1800	19100	146	1.53	1.58	3.70	4.00	16.60	15.00	47	65	4.00	4.00	280	63
	500			1.56	1.63	3.80	3.80	17.10	16.55	52	63	4.00	4.00		
07/26/80	2100		141	1.66	1.59	3.70	4.00	13.99	17.97	49	59	4.00	4.00	439	155
	600	20000		1.35	1.85	3.70	3.90	17.90	17.10	38	66	4.00	4.00		
	1130			1.82	1.56	3.90	3.90	16.50	17.80	53	53	4.00	4.00	436	123
07/27/80	2200	20000	111	1.78	2.13	3.50	3.40	15.50	17.80	48	50	4.00	4.00		
	700			1.63	1.61	3.90	3.90	17.10	23.90	52	53	4.00	4.00	403	128
	1400			1.58	1.65	3.80	4.00	18.20	15.80	37	60	4.00	4.00		
07/28/80	2200	18800	116	1.66	1.73	3.60	4.00	17.20	16.30	37	62	4.00	4.00		
	400			1.71	1.21	3.70	3.90	17.00	11.40	51	61	4.00	4.00	317	66
	900			1.65	1.85	3.80	4.00	17.00	16.60	45	54	4.00	4.00		
				1.72	2.00	4.00	4.00	17.30	19.30	44	55	4.00	4.00		
				1.65	1.66	3.70	3.70	15.30	15.20	46	55	4.00	4.00		

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TABLE D (continued).

DATE	TIME OF SAMPLE	FEED SLUDGE TOTAL SOLIDS mg/l	FeCl ₃ DOSE lb/ton		FILTER YIELD based on cake solids		SLUDGE pH		CAKE SOLIDS %		FORM TIME sec		CYCLE TIME min		FILTRATE SUSPENDED SOLIDS mg/l	
			TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
07/29/80	2200			1.54	1.84	4.00	4.10	16.70	15.60		42	71	4.00	4.00	401	65
	300	20700	129	1.56	1.92	4.00	4.00	16.70	16.00		44	55	4.00	4.00		
	815			1.59	1.98	3.70	3.70	16.90	15.80		46	55	4.00	4.00		
	1800			2.03	2.23	4.00	4.10	16.20	17.10		42	71	4.00	4.00		
07/30/80	100	19300	169	1.82	2.14	4.00	3.80	16.70	15.40		51	68	4.00	4.00	462	108
	1300	14820	149	1.31	1.51	4.00	4.00	16.30	16.50		34	56	4.00	4.00	379	99
	08/01/80			1.40	1.45	3.80	4.20	16.40	16.50		38	54	4.00	4.00		
	1900	14660	149	1.29	1.50	3.70	3.80	15.60	19.20		35	43	4.00	4.00	166	76
08/02/80	1400			1.51	1.36	3.80	3.90	16.70	16.40		35	44	4.00	4.00		
	2100			1.00	1.32	3.90	4.00	11.00	17.70		49	42	4.00	4.00		
	200	14300	127	1.62	1.50	4.00	3.90	14.90	16.80		49	44	4.00	4.00	154	52
	1000			1.29	1.30	3.90	3.80	15.50	17.20		48	39	4.00	4.00		
08/04/80	1700			1.64	1.33	4.00	3.80	16.60	16.80		45	41	4.00	4.00	182	87
	0	14770	147	1.50	1.43	3.90	3.90	16.80	17.20		43	46	4.00	4.00		
	800			1.29	1.40	3.80	3.80	17.40	15.80		39	47	4.00	4.00		
	1600			1.41	1.43	4.20	3.80	14.80	15.50		36	49	4.00	4.00		
08/05/80	1400	15700	146	1.58	1.58	3.70	3.80	17.90	15.80		41	52	4.00	4.00	149	55
	2100			1.60	1.60	3.90	4.00	18.20	16.00		41	50	4.00	4.00		
	500	14920	144	1.81	1.65	4.20	4.20	17.70	16.90		43	50	4.00	4.00	211	154
	100	15130	144	1.77	1.24	4.20	3.50	18.30	14.60		41	45	4.00	4.00	321	68
08/07/80	500			1.74	1.36	3.90	3.50	14.40	16.90		40	49	4.00	4.00		
	1500			1.76	1.67	4.50	3.80	15.40	14.70		50	46	4.00	4.00		
	1630			1.78	1.46	4.30	4.00	16.40	15.24		50	50	4.00	4.00		

APPENDIX E

FILTER YIELD AND SLUDGE CONDITIONING DATA

Table E lists date, time of sample, elapsed time of filter operation (hours), filter cake solids (percent total solids), filter yields (A) - based on sludge flow rate (lb/hr/ft²), filter yield (B) - based on filter cake solids, ferric chloride dose (lb/ton d.s.), and solids recovery (percent) for the top feed filter and bottom feed filter. Also included is the ferric chloride dose (lb/ton dry solids) for the Jones Island Filter.

Data under the top feed (TF) filter heading from 3/24/80 (0800 hrs) to 4/7/80 (0700 hrs) and data under the bottom feed (BF) filter heading from 4/7/80 (1500 hrs) to 4/20/80 (0600 hrs) are from Jones Island production filters.

TABLE E. TOP FEED FILTER AND BOTTOM FEED FILTER YIELD AND SLUDGE CONDITIONING
DATA FOR THE PERIOD FROM 6/26/79 TO 8/7/80.

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS (% solids)		FILTER YIELD (A) (lb/hr/ft ²)		FILTER YIELD (B) (lb/hr/ft ²)		FeCl ₃ CONDITIONING (lb/ton sludge)*		SOLIDS RECOVERY (%)	
		IF	BF	IF	BF	IF	BF	IF	BF	IF	BF	IF	BF
06/26/79	1900	24	24	17.06	14.20	1.05	1.05	1.23	1.54	-	-	99.9	99.9
	2330			16.54	14.60			1.26	1.45	-	-		
	330	48	48	17.02	14.20	.97	.97	1.21	1.54	-	-	99.7	99.9
	700			17.21	14.60			1.28	1.45	-	-		
	1000			17.22	15.43			1.26	1.41	-	-		
06/27/79	1300			17.13	13.72			1.23	1.42	-	-		
	1600			16.88	15.02			1.23	1.39	-	-		
	2000			16.29	14.70			1.25	1.37	-	-		
	400	72	72	14.95	13.77	-	-	1.08	1.43	-	-	99.9	99.9
	800			16.70	14.75			1.26	1.48	-	-		
06/28/79	1200			17.42	15.55			1.32	1.46	-	-		
	1500			17.27	15.39			1.23	1.38	-	-		
	1900			16.10	15.40			1.36	1.31	-	-		
	2300			16.50	15.20			1.24	1.40	-	-		
	2300	96	93	16.90	15.40	-	-	1.20	1.32	-	-	99.8	99.8
06/29/79	600			17.10	15.30			1.20	1.36	-	-		
	900			16.80	16.10			1.23	1.26	-	-		
	1400			17.00	15.60			1.29	1.21	-	-		
	1800			16.40	14.90			1.21	1.41	-	-		
	2200			18.90	18.00			1.28	1.17	-	-		
06/30/79	700	120	117	16.30	14.60	-	-	1.24	1.37	-	-	99.9	99.9
	1900			15.80	14.50			1.17	1.26	-	-		
	2300			15.90	14.80			1.20	1.37	-	-		
	300	144	141	16.20	14.50	-	-	1.18	1.35	141	141	99.8	99.7
	1000			16.00	15.10			1.20	1.32	-	-		
07/02/79	1800			13.50	15.00			1.08	1.27	-	-		
	0	152	165	16.20	14.70	-	-	1.12	1.33	145	145	99.9	99.7
	1600			-	14.70			-	1.34	-	-		
	2000			15.20	14.80			1.29	1.24	-	-		
	400	160	184	15.20	15.40	-	-	1.12	1.12	86	86	99.9	99.3
07/03/79	1400			13.90	13.90	-	-	1.43	1.43	-	-		
	1800			15.30	-	-	-	1.36	-	-	-		
	300	184	184	16.10	-	-	-	1.31	-	-	-		
	1100			15.50	-	-	-	1.45	-	-	-		
	1800			14.90	-	-	-	1.60	-	-	-		
07/04/79	200	208	184	14.40	-	-	-	1.42	-	-	-		
	1030			14.20	-	-	-	1.57	-	-	-		
	1700			16.00	-	-	-	-	-	-	-		
	200	210	208	16.90	16.00	-	-	1.45	1.45	145	145	99.6	99.9
	1800			15.50	15.10	-	-	1.42	1.42	162	162	99.9	99.9
07/12/79	200	222	232	15.20	14.90	1.44	-	1.38	1.23	136	136	99.9	99.8
	900			15.20	14.90			1.33	1.27	-	-		
	1700	232	244	14.30	15.10	1.63	-	1.21	1.35	144	144	99.9	99.9
	1600			14.60	15.50			1.41	1.22	-	-		
	2300			15.90	15.20			1.28	1.25	-	-		
07/13/79	700	256	268	16.00	15.90	1.33	-	1.33	1.23	137	137	99.8	99.8
	1500			15.50	15.70			1.21	1.33	-	-		
	2200			15.60	15.60			1.37	1.23	-	-		
	600	277	289	16.60	16.60	1.13	-	1.17	1.22	146	146	99.5	99.7
	1400			14.80	14.80			1.30	1.11	-	-		
07/18/79	1430	322	305	14.40	15.80	1.46	1.31	1.42	1.13	148	148	99.8	99.9
	1900			15.90	15.90			1.51	1.12	-	-		
	300	337	319	14.40	15.10	1.24	1.03	1.37	1.21	172	172	99.9	99.9
	2100			12.40	13.60			1.24	.94	-	-		
	07/20/79	346	328	14.10	14.00	1.17	-	1.10	.95	160	160	99.9	99.9

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS (%)		FILTER YIELD (A) (lb/hr/ft ²)		FILTER YIELD (B) (lb/hr/ft ²)		FeCl ₃ CONDITIONING (lb/ton sludge)		SOLIDS RECOVERY (%)	
		TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
07/22/79	1600	346	350	-	13.60	-	1.22	-	1.13	179	179	99.9	99.9
07/23/79	1630	346	374	-	15.50	-	1.15	-	.92	154	154	99.9	99.8
07/24/79	2200	346	398	-	14.10	-	-	-	1.08	145	145	99.9	99.7
07/25/79	1600	346	398	-	14.40	-	1.26	-	1.03	145	145	99.9	99.7
07/26/79	1630	352	407	-	14.30	-	-	-	1.07	145	145	99.9	99.7
07/27/79	1700	366	431	-	14.10	-	-	-	1.07	145	145	99.9	99.7
07/29/79	1815	390	459	13.70	11.30	1.27	-	1.27	-	132	132	99.9	99.9
07/30/79	1600	400	479	13.50	13.80	1.17	-	-	1.08	152	152	99.9	99.9
07/31/79	1600	424	503	13.20	13.40	1.01	-	-	1.21	179	179	99.5	99.6
08/01/79	1800	441	527	14.90	12.70	-	-	1.44	1.11	179	179	99.5	99.6
08/02/79	2100	465	551	14.30	14.10	1.03	-	1.12	1.19	173	173	99.9	99.3
08/03/79	2000	470	569	14.30	14.30	1.86	-	1.44	1.25	158	158	99.7	99.9
08/04/79	2130	475	593	15.10	15.10	1.24	1.11	1.45	1.30	166	166	99.8	99.1
08/05/79	2000	486	617	15.10	15.30	-	-	1.31	1.35	166	166	99.8	99.1
08/06/79	1700	492	641	14.60	15.20	1.20	1.25	1.35	1.21	153	153	99.8	99.8
08/07/79	1800	516	665	13.10	14.10	-	-	1.48	1.18	153	153	99.8	99.8
08/08/79	2300	528	675	13.10	14.10	1.15	1.24	1.36	1.16	189	189	99.7	99.6
08/09/79	2200	552	699	13.40	14.40	1.37	1.38	1.37	1.13	189	189	99.7	99.6
08/10/79	2100	568	723	12.70	14.40	1.20	1.37	1.36	1.16	155	155	99.6	99.3
08/11/79	2200	592	747	12.00	14.30	1.30	1.39	1.16	1.03	188	188	99.9	99.9
08/12/79	2000	616	771	14.10	14.40	-	-	1.05	1.07	181	181	99.6	99.6
08/13/79	2000	636	791	11.40	13.60	1.30	1.39	.98	1.02	152	152	99.7	99.7
08/14/79	1800	660	815	16.10	14.30	1.59	1.65	1.26	1.28	157	157	99.7	99.6
08/15/79	1800	684	839	14.10	14.40	1.57	1.64	1.35	1.34	157	157	99.7	99.6
08/16/79	1800	700	855	14.40	14.40	1.44	1.44	1.44	1.26	157	157	99.7	99.6
08/17/79	1800	716	871	14.90	14.90	1.18	1.44	1.51	1.28	153	153	99.5	99.4
08/18/79	1800	732	887	15.80	15.80	1.59	1.65	1.55	1.38	153	153	99.6	99.5
08/19/79	1800	748	903	15.90	15.30	1.57	1.64	1.49	1.42	153	153	99.6	99.5
08/20/79	1800	764	919	14.50	15.40	1.57	1.64	1.57	1.48	145	145	99.6	99.8
08/21/79	1800	780	935	13.40	16.00	1.57	1.64	1.71	1.52	145	145	99.6	99.8
08/22/79	1800	796	951	16.20	16.00	1.50	1.56	1.61	1.55	158	158	99.5	99.5
08/23/79	1800	812	967	16.30	16.00	1.75	1.73	1.67	1.52	158	158	99.5	99.5
08/24/79	1800	828	983	16.10	16.00	1.54	1.52	1.61	1.56	129	129	87.2	99.6
08/25/79	1800	844	1000	15.20	15.10	1.54	1.52	1.61	1.56	129	129	87.2	99.6
08/26/79	1800	860	1016	15.40	14.80	1.54	1.52	1.69	1.64	134	134	99.7	99.4
08/27/79	1800	876	1032	15.40	14.80	1.54	1.52	1.64	1.64	134	134	99.7	99.4
08/28/79	1800	892	1048	14.90	12.90	1.41	1.39	1.66	1.45	134	134	99.7	99.4
08/29/79	1800	908	1064	15.40	15.00	1.41	1.39	1.41	1.39	134	134	99.7	99.4

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION	FILTER CAKE SOLIDS		FILTER YIELD (A)		FILTER YIELD (B)		FeCl ₃ CONDITIONING		SOLIDS RECOVERY	
			TF	BF	TF	BF	TF	BF	JI	IF	TF	BF
08/16/79	2300		17.00	15.60			1.65	1.25				
	900	708	863		1.23	1.27	1.52	1.40	130	130	99.5	98.8
	1500		15.20	14.40			1.32	1.18				
	2200		14.80	14.90			1.24	1.15				
08/17/79	400	726	881		1.24	1.24	1.39	1.11	140	140	99.4	99.1
	1400		15.00	14.20			1.13	1.10				
	2100		15.60	15.00			1.21	1.17				
	500	750	905		1.12	1.12	1.35	1.13	141	141	99.6	99.7
08/18/79	1300		14.80	15.60			1.20	1.09				
	2000		14.50	15.40			1.25	1.07				
	400	774	929		.92	1.03	1.13	1.03	150	150	99.6	99.7
	1200		13.40	15.60			1.18	1.02				
08/20/79	1900		15.20	15.30			1.28	.96	122	122	99.6	99.8
	300	794	953		1.02	1.07	1.33	1.03				
	1100		13.20	15.50			1.01	1.04				
	2300		16.70	15.70			.99	.99				
08/21/79	2200	806	965		1.01	1.08	1.32	1.17	144	144	99.3	99.4
	500	830	989		1.35	1.33	1.29	1.16	135	135	99.7	99.8
	1300		16.40	16.90			1.35	1.25				
	2000		16.30	16.10			1.56	1.31				
08/23/79	300	854	1013		1.26	1.24	1.31	1.25	136	136	99.8	99.7
	1100		16.10	15.90			1.24	1.16				
	1800		15.90	16.30			1.33	1.30	136	136	99.7	99.7
	900	878	1037		1.21	1.20	1.27	1.22				
08/24/79	1700		14.50	15.30			1.28	1.23				
	0	898	1055		1.39	1.41	1.23	1.28	141	141	99.6	99.6
	800		16.40	14.90			1.23	1.16				
	1600		15.60	14.20			1.23	1.32				
08/26/79	2300		13.90	14.50			1.54	1.32				
	1400	922	1079		1.22	1.31	1.36	1.29	132	132	99.8	99.7
	2100		15.80	14.40			1.24	1.33				
	1030	940	1139		1.15	1.28	1.18	1.33	174	174	97.2	99.5
09/01/79	1500		16.60	17.80			1.71	1.21				
	1700		19.60	14.20			1.26	1.09				
	0	964	1163		1.22	1.28	1.34	1.16	204	204	98.5	99.7
	800		16.70	14.40			1.16	1.08				
09/02/79	1600		15.50	10.10			1.21	.79				
	2300		14.10	14.90			1.17	1.22				
	600	988	1187		1.07	1.25	1.39	1.25	198	198	98.7	99.7
	1400		16.70	13.60			1.29	1.15				
09/03/79	2100		14.30	15.10			1.26	1.17				
	0		14.20	15.90			1.42	1.11				
	800		-	-			-	-	194	194	99.9	85.6
	1600		14.70	14.70			1.14	1.14	199	199	99.9	99.0
09/04/79	200	988	1230		-	1.40	1.21	1.23	190	190	99.7	99.7
	1800		15.30	15.00			-	1.27				
	300	1010	1254		1.05	1.39	1.40	1.43	190	190	99.7	99.7
	700		16.20	15.30			1.53	1.45				
09/05/79	1000		15.70	15.70			1.42	1.36				
	1500		15.90	15.40			1.51	1.45				
	2200		15.60	14.90			1.45	1.46				
	500	1027	1278		1.33	1.50	1.81	1.52	251	251	99.6	99.6
09/07/79	1800		13.70	14.70			1.47	1.41				
	2200		15.40	15.30			1.46	1.45				
	300	1051	1302		1.45	1.44	1.46	1.45	157	157	99.3	99.3
	0		15.60	13.90			1.43	1.40				

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS (Z solids)		FILTER YIELD (A) (lb/hr/ft ²)		FILTER YIELD (B) (lb/hr/ft ²)		FEC13 CONDITIONING (lb/ton sludge)		SOLIDS RECOVERY (Z)	
		TF	BF	TF	BF	TF	BF	TF	BF	JI	TF	BF	TF
09/09/79	1100			15.60	13.90			1.34	1.33				
	1800			15.20	13.50			1.36	1.35				
	1900	1075	1321	15.50	15.10	1.38	1.54	1.33	1.74	173	173	173	99.2 99.6
	1700			16.40	15.30			1.32	1.35				
09/10/79	0	1094	1345	20.50	15.70	1.53	1.58	2.20	1.64	168	168	168	99.5 99.5
	800			21.60	15.90			2.48	1.63				
	1800			19.40	23.40			1.63	2.46				
	1400	1113	1369	24.70	23.50	1.32	1.37	2.10	2.20	177	177	177	99.6 99.5
09/12/79	2100			14.40	14.40				1.44				
	400	1133	1393	14.90	14.40	1.20	1.27	1.41	1.31				
	1200			14.20	13.50			1.41	1.39	185	185	185	99.5 99.4
	1700			13.50	13.50			1.36	1.26				
09/13/79	400	1153	1417	15.50	14.40	1.18	1.21	1.39	1.28	195	195	195	99.5 99.5
	1000			14.10	13.20			1.23	1.23				
	1800			12.50	12.10			1.32	1.22				
	300	1167	1441	13.90	12.90	1.08	1.25	1.33	1.27	188	188	188	99.3 99.4
09/14/79	1600			13.20	14.50			1.17	1.37				
	2000			14.20	13.20			1.34	1.29				
	500	1191	1465	13.10	13.20	1.23	1.27	1.43	1.28	209	209	209	99.2 99.3
	1100			13.30	13.50			1.46	1.31				
09/15/79	800			12.90	13.10			1.48	1.37				
	300	1208	1481	13.50	13.30	1.00	1.32	1.44	1.35	186	188	188	99.3 99.5
	1300	1232	1502	14.60	14.00	1.17	1.47	1.34	1.30	191	191	191	99.6 99.5
	1700			14.00	12.80			1.30	1.31				
09/16/79	100	1256	1526	13.30	13.60	1.30	1.32	1.42	1.37	170	170	170	99.3 99.6
	900			13.00	13.30			1.41	1.42				
	1700			14.60	13.60			1.38	1.38				
	0	1280	1550	15.10	14.00	1.30	1.38	1.31	1.34	171	171	171	99.3 99.5
09/18/79	800			13.10	14.10			1.33	1.27				
	1600			14.30	13.50			1.40	1.42				
	2300			13.80	13.60			1.45	1.41				
	1800	1298	1571	13.60	14.10	1.33	1.37	1.44	1.40	172	172	172	99.2 99.5
09/20/79	2200			15.30	14.20			1.29	1.22				
	700			15.50	14.50			1.22	1.18				
	1800	1322	1595	15.00	14.60	1.17	1.17	1.23	1.22	206	206	206	99.3 99.5
	1400			14.40	14.10			1.25	1.28				
09/21/79	2100			15.10	13.90			1.19	1.29	189	189	189	99.0 99.5
	600	1346	1619	14.60	11.40	1.17	1.20	1.12	1.14				
	1300			10.60	16.40			1.21	1.50				
	2000			15.50	14.40			1.29	1.33				
09/22/79	400	1370	1643	13.70	14.00	1.22	1.19	1.40	1.36	198	198	198	99.4 99.2
	1200			14.00	14.80			1.32	1.19				
	1900			13.10	14.10			1.41	1.38				
	300	1379	1654	14.60	13.30	1.06	1.12	1.35	1.34	205	205	205	99.5 99.4
09/24/79	100	1403	1677	14.89	14.91	1.48	1.47	1.54	1.44	88	88	88	99.7 99.8
	900			15.18	15.01			1.36	1.28				
	1700			15.16	15.16			1.48	1.40				
	2100			15.07	15.41			1.58	1.42				
02/20/80	0	1427	1701	14.89	14.91	1.04	1.42	1.38	1.31	80	80	80	99.7 99.8
	800			14.65	16.28			1.29	1.35				
	1600			13.05	15.36			1.34	1.35				
	2230	1429	1725	15.04	14.62	1.41	1.40	1.35	1.31	83	83	83	99.3 99.5

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION	FILTER CAKE SOLIDS		FILTER YIELD (A)		FILTER YIELD (B)		FeCl ₃ CONDITIONING		SOLIDS RECOVERY	
			(% solids)	TF	(lb/hr/ft ²)	BF	(lb/hr/ft ²)	TF	JI	TF	IF	RF
02/22/80	200	1453	15.59	1742	1.36	1.38	1.23	1.33	73	73	99.3	99.3
	400		15.32				1.30	1.30				
	600		15.69				1.40	1.36				
	1630		15.72				1.33	1.39				
	2100		15.43				1.37	1.28				
02/23/80	500	1477	17.71	1766	2.06	1.47	1.70	1.51	76	76	99.3	99.5
	1300		15.25				1.58	1.40				
	1300		14.91				1.50	1.39				
	2000		15.06				1.70	1.40				
	400	1501	16.43	1790	1.55	1.54	1.82	1.40	78	78	99.5	99.8
02/24/80	1200		15.13				1.76	1.35				
	1900		14.47				1.72	1.47				
	300	1525	15.30	1814	1.39	1.45	1.64	1.51	74	74	99.6	99.9
	1100		15.84				1.55	1.20				
	1800		15.49				1.63	1.40				
02/26/80	200	1532	14.91	1821	1.17	1.11	1.29	1.13	92	92	99.5	99.5
	1200		15.57				1.40	1.22				
	1700	1547	15.33	1836	1.28	1.25	1.44	1.29	78	78	99.7	99.2
	2000		15.62				1.39	1.21				
	800	1563	15.43	1860	1.27	1.28	1.32	1.22	77	77	99.5	99.7
02/28/80	800		15.45				1.35	1.17				
	1200		14.00				1.29	1.13				
	1500	1578	14.80	1884	1.29	1.27	1.43	1.20	83	83	98.8	99.4
	2200		15.20				1.30	1.33				
	300	1598	17.20	1908	1.33	1.37	1.49	1.22	86	86	99.4	99.8
03/01/80	100		15.20				1.35	1.32				
	300		14.90				1.38	1.15				
	600		14.80				1.44	1.30				
	830		15.00				1.45	1.40				
	2100	1622	15.70	1927	1.37	1.45	1.29	1.18	79	79	99.7	99.8
03/02/80	900		14.40				1.37	1.34				
	1300		13.60				1.44	1.35				
	1800		14.90				1.57	1.29				
	2200		13.20				1.55	1.31				
	400	1641	14.60	1951	1.33	1.32	1.30	1.07	93	93	99.5	99.8
03/03/80	1200		13.50				1.69	1.25				
	1900		13.10				1.68	1.19				
	200	1665	13.90	1975	1.35	1.25	1.13	1.13	85	85	99.6	99.7
	900		14.60				1.45	1.28				
	1700	1689	14.00	1999	.98	.96	1.57	1.35	77	77	99.3	99.7
03/04/80	800		13.70				1.48	1.27				
	1600		13.90				1.42	1.30				
	2300		13.60				1.58	1.38				
	700	1698	13.90	2013	1.27	1.40	1.50	1.34	79	79	99.4	99.5
	2200	1705	12.76	2039	1.57	1.42	1.30	1.41	94	94	98.2	99.4
03/05/80	100	1729	14.69	2063	1.42	1.37	1.41	1.22	94	94	99.3	99.8
	400		12.93				1.48	1.18				
	1200		12.93				1.39	1.16				
	1900		13.75				1.45	1.33				
	300	1753	13.13	2087	1.38	1.34	1.60	1.30	93	93	99.5	99.8
03/06/80	1100		14.10				1.44	1.25				
	1800		12.95				1.48	1.32				
	200	1771	13.45	2108	1.38	1.34	1.52	1.31	90	90	99.4	99.8
	1000		13.69				1.38	1.27				
			13.89				1.24	1.25				

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS (% Solids)		FILTER YIELD (A) (lb/hr/ft ²)		FILTER YIELD (B) (lb/hr/ft ²)		FeCl ₃ CONDITIONING (lb/ton sludge)		SOLIDS RECOVERY (%)	
		TF	BF	TF	BF	TF	BF	TF	BF	J1	TF	TF	BF
03/12/80	1800			13.71	13.37	1.30	1.25	1.30	1.25				
	400	1792	2131	15.43	15.77	1.15	1.12	1.14	.99	92	92	99.3	99.8
	1100			14.10	20.74			1.29	1.32				
03/13/80	1800			13.86	16.76	1.15	1.27	1.35	.98				
	1100	1803	2154	15.29	13.76			1.45	.91	94	94	99.4	99.3
	900			19.47	18.01	1.37	1.22	1.37	1.22				
03/14/80	2000			16.95	17.09	1.38	1.36	1.34	1.18	82	82	99.4	99.8
	400	1818	2178	17.76	18.11			1.24	1.27				
	1800			14.71	15.53	1.41	1.11	1.41	1.11				
03/15/80	2200			14.22	15.24	1.39	1.12	1.39	1.12				
	0	1837	2202	14.78	15.23	1.19	1.14	1.30	1.11	88	88	99.5	99.7
	800			12.56	14.56			1.50	1.14				
03/16/80	2300			14.30	14.44	1.31	1.25	1.28	1.22				
	600	1859	2226	13.52	14.82			1.46	1.13	88	88	99.5	99.8
	1500			14.50	14.70	1.45	1.28	1.45	1.28				
03/17/80	2100			15.89	15.40	1.33	1.31	1.33	1.31				
	500	1866	2234	15.92	15.54	1.33	1.23	1.31	1.17	79	79	99.6	99.7
	700	1886	2257	19.50	16.90	1.30	1.28	1.31	1.15	87	87	99.6	99.5
03/18/80	1500			15.60	16.00	1.30	1.08	1.30	1.08				
	2200			15.50	16.20	1.35	1.19	1.35	1.19				
	400	1910	2281	15.50	16.20	1.25	1.25	1.64	1.44	117	117	99.5	99.7
03/19/80	1200			15.40	15.90	1.69	1.45	1.69	1.45				
	1900			15.40	15.80	1.89	1.62	1.89	1.62				
	100	1934	2305	15.50	15.70	1.08	1.09	1.83	1.70	139	139	99.5	99.6
03/20/80	900			14.00	15.30	1.94	1.69	1.94	1.69				
	1700			14.61	14.68	1.57	1.30	1.57	1.30				
	0	1958	2329	13.85	14.77	1.53	1.54	1.61	1.44	95	95	99.6	99.5
03/21/80	800			12.84	13.23	1.53	1.32	1.53	1.32				
	1600			13.96	13.70	1.36	1.35	1.36	1.35				
	2300			13.01	14.04	1.71	1.42	1.71	1.42				
03/22/80	700	1982	2353	13.47	14.65	1.56	1.58	1.62	1.34	93	93	99.7	99.8
	1500			13.13	13.72	1.57	1.41	1.57	1.41				
	2200			13.34	14.20	1.56	1.34	1.56	1.34				
03/23/80	600	2006	2377	14.25	15.11	1.48	1.42	1.49	1.20	96	96	99.7	99.8
	1400			13.81	11.11	1.65	1.35	1.65	1.35				
	2100			13.46	13.33	1.59	1.47	1.59	1.47				
03/24/80	500	2030	2401	14.20	14.78	1.41	1.46	1.56	1.34	101	101	99.5	99.8
	1300			14.29	15.31	1.48	1.27	1.48	1.27				
	2000			14.56	15.37	1.56	1.33	1.56	1.33				
03/25/80	400	2048	2417	14.80	15.00	1.41	1.72	1.59	1.43	85	85	99.6	99.4
	1900			14.10	14.50	1.60	1.42	1.60	1.42				
	300	2072	2441	14.10	14.60	1.39	1.44	1.58	1.58	103	103	99.7	99.7
03/26/80	1100			12.10	12.40	1.35	1.25	1.35	1.25				
	1800			12.80	13.40	1.38	1.29	1.38	1.29				
	2000	2083	2451	12.60	12.80	1.59	1.47	1.43	1.32	91	-	99.6	99.5
03/27/80	900			13.80	14.30	1.50	1.44	1.50	1.44				
	800	2083	2470	12.60	14.70	-	1.75	1.38	1.50	255	-	99.9	99.3
	2100			11.90	13.00	1.31	1.63	1.31	1.63				
03/29/80	300	2083	2494	12.00	13.50	-	1.72	1.38	1.63	263	-	99.9	99.6
	800			11.70	14.90	1.19	1.40	1.19	1.40				
	1600			11.70	13.50	1.43	1.62	1.43	1.62				
03/30/80	2300			11.40	9.40	1.36	1.05	1.36	1.05				
	700	2083	2518	12.90	13.40	1.67	1.67	1.34	1.57	291	-	99.9	99.7
	1500			14.10	17.50	1.53	2.14	1.53	2.14				

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS (%)		FILTER YIELD (A) (lb/hr/ft ²)		FILTER YIELD (B) (lb/hr/ft ²)		FeCl ₃ CONDITIONING (lb/ton sludge)		SOLIDS RECOVERY (%)	
		IF	BF	IF	BF	IF	BF	IF	BF	IF	BF	IF	BF
03/31/80	2000			13.00	12.40			1.36	1.45	288	-	142	99.9
	600	2083	2542	13.30	13.70	-	1.96	1.43	1.65				99.8
	1400			12.50	14.10			1.38	1.60				
04/01/80	2100			13.40	13.90			1.40	1.73				
	3000	2083	2561	13.70	14.90	-	1.92	1.49	1.59	122	-	182	99.9
	1000	2089	2601	12.10	14.10	2.02	1.83	1.47	1.90	90	122	80	99.7
04/03/80	2230			12.70	14.60			1.22	1.74				
	3000	2105	2625	13.70	13.30	2.22	2.03	1.44	1.47	88	85	114	99.8
	600			12.60	13.80			1.15	1.56				
04/05/80	800			13.60	12.80			1.36	1.63				
	1400	2105	2649	12.60	13.10	-	2.07	1.27	1.66	85	-	115	99.9
	2200			13.70	15.50			1.54	1.63				
04/06/80	500	2105	2673	13.80	14.90	-	1.97	1.52	1.62	92	-	123	99.9
	1300			13.70	14.40			1.54	1.78				
	2000			11.40	14.60			1.28	1.66				
04/07/80	700	2108	2683	14.60	14.40	2.38	1.76	1.51	1.72	85	48	139	99.7
	1500			15.20	14.30			1.62	1.52				
	2000	2132	2683	15.30	14.10	1.81	-	1.45	1.55	90	101	-	99.4
04/08/80	600			15.10	14.40			1.57	1.61				
	1100			13.50	14.90			1.67	1.59				
	1900			15.10	15.50			1.78	1.58				
04/09/80	100	2148	2683	15.00	15.30	1.73	-	1.82	1.70	76	93	-	99.5
	900			14.60	14.90			1.71	1.64				
	2400			16.80	15.80			1.73	1.31				
04/10/80	800	2172	2683	15.20	14.30	1.75	-	1.59	1.68	76	82	-	99.6
	1600			14.20	14.70			1.78	1.71				
	7000	2191	2683	14.00	14.80	1.93	-	1.77	1.64	82	100	-	98.9
04/12/80	1500			12.60	14.80			1.75	1.50				
	600	2211	2683	13.80	14.60	1.84	-	1.95	1.65	95	108	-	99.7
	1400			14.30	14.80			1.97	1.55				
04/13/80	2100			14.40	17.60			1.93	1.49				
	500	2235	2683	15.70	16.40	1.80	-	1.55	1.82	90	112	-	99.6
	1300			14.20	13.80			1.92	1.72				
04/14/80	2200			10.10	14.50			1.14	1.62				
	500	2259	2683	16.90	16.20	1.86	-	2.29	1.99	85	108	-	99.7
	1200			14.90	14.60			1.92	1.56				
04/15/80	1900			14.80	14.00			1.84	1.65				
	300	2283	2683	15.10	14.30	1.85	-	1.99	1.80	93	107	-	99.7
	1100			14.90	14.20			1.91	1.04				
04/16/80	1800			15.00	14.60			2.04	1.67				
	200	2307	2683	15.50	14.20	1.83	-	1.90	1.82	93	127	-	99.5
	1000			14.70	14.20			2.16	1.77				
04/17/80	1800			14.40	14.10			2.11	1.77				
	100	2331	2683	14.80	13.20	2.01	-	1.97	1.82	95	120	-	99.6
	900			13.60	12.60			2.22	1.86				
04/18/80	1700			13.50	12.90			2.17	1.74				
	0	2353	2683	13.70	13.80	1.84	-	2.19	1.48	115	121	-	99.6
	800			14.20	14.70			2.05	1.39				
04/20/80	1600			14.50	14.10			1.74	1.94				
	2300			14.70	13.90			1.81	1.79				
	600	2372	2706	14.90	15.50	1.57	1.51	1.83	1.11	125	118	158	99.1
04/21/80	2000	2381	2716	13.80	19.50	1.82	2.08	1.63	1.39	130	133	124	99.9
	1000	2395	2732	15.30	15.80	1.67	1.74	1.55	1.25	132	135	102	99.6
	2100			15.60	16.10			1.76	1.30				

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS (% solids)		FILTER YIELD (A) (lb/hr/ft ²)		FILTER YIELD (B) (lb/hr/ft ²)		FEC13 CONDITIONING (lb/ton sludge)		SOLIDS RECOVERY (%)	
04/23/80	200	2419	2756	16.20	15.70	1.43	1.40	1.48	1.38	133	149	99.6	99.7
04/24/80	200	2436	2780	14.80	15.30	1.46	1.50	1.43	1.36	119	133	99.5	99.7
04/25/80	200	2445	2804	14.40	14.10	1.37	1.34	1.51	1.39	132	129	99.2	99.5
04/26/80	200	2469	2828	13.80	15.00	1.52	1.53	1.50	1.36	136	145	99.5	99.5
04/27/80	200	2492	2851	12.90	13.70	1.65	1.53	1.68	1.35	112	144	99.5	99.6
04/28/80	200	2516	2871	12.70	13.50	1.75	1.65	2.02	1.31	130	135	99.6	99.7
05/01/80	200	2533	2894	13.00	14.50	1.58	1.55	1.94	1.53	148	168	99.9	99.9
05/02/80	200	2553	2918	12.60	14.00	1.83	1.73	2.16	1.64	110	145	99.3	99.7
05/03/80	200	2567	2929	13.50	14.40	1.82	1.76	1.98	1.52	114	143	99.6	99.5
05/09/80	200	2602	2999	12.90	13.80	1.60	1.63	1.93	1.63	137	137	99.5	99.6
05/11/80	200	2611	3005	14.20	14.20	1.52	1.54	1.61	1.47	138	138	99.2	99.6
05/12/80	200	2622	3012	13.80	14.40	1.64	1.56	1.76	1.43	144	144	99.4	99.7
05/13/80	200	2634	3036	13.90	15.70	1.41	1.51	1.57	1.40	144	144	99.3	99.7
05/14/80	200	2656	3060	15.50	15.50	1.54	1.76	1.38	1.37	135	135	99.3	99.8
05/15/80	200	2664	3084	15.99	15.12	1.59	1.69	1.66	1.60	132	132	98.7	99.5
05/16/80	200	2688	3094	16.12	15.18	1.40	1.58	1.64	1.57	176	176	99.2	99.6
05/17/80	200	2712	3118	15.80	14.60	1.33	1.56	1.56	1.46	145	145	99.0	99.7
05/18/80	200	2736	3142	15.50	16.20	1.33	1.58	1.38	1.48	126	126	99.3	99.7
05/19/80	200	2752	3163	15.20	15.20	1.27	1.50	1.43	1.39	133	-	99.3	99.7
05/20/80	200	2770	3183	14.40	16.20	1.50	1.61	1.53	1.42	128	30	99.6	99.8
05/21/80	200	2788	3207	15.40	17.40	1.46	1.78	1.49	1.56	136	42	99.6	99.7
05/22/80	200	2812	3231	15.90	16.00	1.56	1.70	1.44	1.43	149	31	99.2	99.5
05/23/80	200	2836	3246	16.20	15.20	1.71	1.62	1.77	1.26	162	38	99.4	99.2

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS		FILTER YIELD (A)		FILTER YIELD (B)		FeCl ₃ CONDITIONING		SOLIDS RECOVERY	
		TF	BF	TF	BF	TF	BF	TF	BF	JI	TF	TF	BF
05/24/80	400	2859	3266	14.90	14.40	1.66	1.82	1.62	1.59	119	185	99.4	99.6
	1200			12.30	14.60			1.68	1.67				
	1900			13.70	15.00			2.04	1.75				
05/25/80	1100	2865	3266	16.10	15.90	1.82	1.94	1.59	1.46	99	151	99.5	97.6
05/26/80	1700	2868	3279	17.40	16.10	1.73	1.65	1.51	1.40	109	179	99.4	99.8
05/27/80	1930			14.70	16.40			1.27	1.47				
	300	2889	3307	15.80	16.40	1.60	1.34	1.20	1.45	131	168	99.5	99.7
	1000			15.90	16.50			1.64	1.40				
	1800			16.60	15.10			1.66	1.64				
05/29/80	2200	2897	3310	16.80	16.60	-	2.17	2.09	1.90	124	199	99.7	99.8
05/30/80	300	2921	3330	16.40	15.00	2.14	1.43	1.93	1.93	120	196	99.6	99.7
	1300			15.20	16.80			2.17	1.52				
	1800			15.70	14.30			2.16	2.18				
05/31/80	100	2943	3330	13.40	14.10	1.97	-	2.31	2.15	129	196	99.6	99.9
06/01/80	1020	2957	3332	16.00	15.50	1.62	-	1.48	1.22	131	208	99.2	99.5
	2300			14.40	13.90			1.79	1.62				
06/04/80	430	2987	3348	17.60	18.10	1.58	1.30	1.75	1.61	122	200	99.2	98.8
	1400			17.50	16.10			2.04	1.62				
06/05/80	600	2998	3358	16.10	14.60	1.84	1.43	2.46	1.40	119	182	99.1	99.4
	2200			17.70	16.20			1.95	1.58				
06/06/80	400	3007	3366	17.40	17.20	1.30	1.28	2.04	1.62	128	-	99.3	99.6
	800			17.90	15.10			2.48	1.95				
	2100			18.40	17.20			1.73	1.55				
06/07/80	2200	3010	3010	17.30	17.30	1.72	1.72	1.49	1.49	135	-	99.7	99.7
06/08/80	100	3019	3405	19.80	17.70	1.38	1.33	1.86	1.75	123	123	99.4	99.6
	800			17.20	17.60			1.80	1.96				
06/09/80	400	3026	3429	20.60	18.90	1.68	1.48	2.23	1.80	103	103	99.5	99.7
	800			20.60	18.20			2.03	1.91				
	2015			24.30	21.30			1.58	2.08				
06/10/80	1230	3026	3445	23.30	18.70	1.39	96	1.51	2.05	128	128	99.9	99.5
06/12/80	1400	3037	3477	23.60	27.10	1.26	1.27	1.61	2.37	87	87	99.3	99.5
	1800			18.80	26.40			1.20	2.34				
	2100			18.50	15.50			1.22	1.50				
06/13/80	0	3061	3501	18.80	15.70	97	98	1.18	1.45	94	94	99.1	99.7
	800			16.40	14.00			1.01	1.17				
	1600			17.20	15.00			1.16	1.32				
	2300			17.00	13.70			1.05	1.27				
06/14/80	600	3085	3509	15.70	13.90	1.33	1.21	1.13	1.18	93	93	99.2	99.5
06/15/80	2200	3094	3513	19.30	19.10	1.06	1.15	1.27	1.21	136	136	98.9	99.5
06/16/80	100	3118	3537	18.70	17.70	1.09	1.22	1.36	1.37	141	141	99.1	99.7
	700			19.50	18.30			1.18	1.26				
	1500			18.40	17.20			1.44	1.49				
	2200			18.60	17.30			1.48	1.56				
06/17/80	200	3129	3541	18.80	19.60	1.63	1.06	1.53	1.56	132	168	99.3	99.7
	2200			19.00	18.10			1.78	1.74				
06/18/80	400	3153	3565	17.10	16.80	1.64	1.55	2.01	1.81	130	168	99.4	99.6
	1200			16.00	16.50			1.85	1.76				
	1700			17.18	16.10			1.89	1.94				
06/19/80	500	3177	3589	16.90	15.20	1.59	1.45	1.87	1.84	104	167	99.4	99.6
	1300			17.30	16.70			1.74	1.75				
	2000			17.30	17.00			1.86	1.84				
06/20/80	700	3201	3604	16.50	16.90	1.57	1.39	1.83	1.76	113	162	99.4	99.6
	1100			16.60	16.50			1.80	1.69				
	2200			16.80	16.20			2.13	1.80				

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION	FILTER CAKE SOLIDS		FILTER YIELD (A)		FILTER YIELD (B)		FeCl ₃ CONDITIONING		SOLIDS RECOVERY	
			IF	BF	IF	BF	IF	BF	JI	TF	IF	BF
06/21/80	200	3225	17.10	17.60	1.54	1.31	1.84	1.59	103	164	99.4	99.6
	1500	3628	16.60	16.20			1.79	1.65				
06/22/80	2200		16.50	16.50			1.76	1.66				
	400	3243	18.50	17.40	1.50	1.21	1.61	1.56	104	142	99.4	99.6
	1100		16.70	16.70			1.89	1.60				
06/23/80	2100		18.90	17.80			1.69	1.84				
	100	3264	17.50	17.40	1.31	1.05	1.67	1.74	131	185	99.4	99.7
	900		19.40	16.00			1.56	1.92				
06/25/80	1700		19.70	18.10			1.78	2.01				
	400	3287	20.10	17.50	1.89	2.00	1.99	1.58	93	180	99.2	99.4
	1200		18.50	18.40			2.21	1.81				
06/26/80	1900		18.30	17.80			2.47	2.13				
	400	3311	18.10	18.50	2.09	2.04	2.46	1.93	101	165	99.5	99.6
	1100		17.80	18.80			2.27	1.76				
06/27/80	1800		17.10	18.30			2.47	1.91				
	100	3325	17.40	17.90	1.88	1.90	2.14	1.60	89	159	99.5	99.7
	1000		17.30	16.60			1.88	1.74				
06/28/80	1700		17.10	17.80			2.14	1.67				
	200	3359	18.60	18.90	1.84	1.85	1.84	1.44	91	158	99.2	99.5
	1000		17.80	18.20			2.12	1.60				
06/29/80	300	3383	19.10	19.80			2.05	1.63				
	1200		18.40	18.70	2.07	2.08	2.14	1.76	76	125	99.5	99.6
	1900		17.60	17.30			2.24	1.83				
06/30/80	400	3407	18.20	19.00	1.85	2.00	2.22	1.79				
	1200		17.90	18.10			2.21	1.75	72	136	99.3	99.6
07/01/80	500	3331	18.10	18.00	1.82	1.96	2.07	1.83				
	1300		17.40	17.40			2.20	1.93	82	144	99.5	99.5
	2100		18.35	17.50			1.99	1.62				
07/02/80	300	3347	18.08	18.13			2.21	1.71				
	1500		19.09	19.23	1.76	1.97	2.09	1.69	81	153	99.6	99.5
	2200		18.80	19.00			1.90	1.65				
07/03/80	700	3371	18.60	18.00	1.65	1.62	1.92	1.66				
	1400		18.20	18.60			2.03	1.59	81	130	99.3	99.3
	2300		17.10	16.40			1.74	1.34				
07/04/80	400	3395	17.60	16.90			1.70	1.29				
07/09/80	600	3471	17.40	16.30	1.57	1.44	1.72	1.21	127	170	99.3	99.4
	1400		18.80	18.00	1.87	1.65	1.40	1.40	103	150	99.9	99.9
	2100		17.90	16.30			1.51	1.43				
07/10/80	200	3484	18.20	17.80			1.45	.99				
	2100		18.80	18.20	1.79	1.68	1.04	1.51	80	169	99.9	99.9
07/11/80	800	3508	17.50	17.20			1.56	1.45				
	1600		11.75	13.16	1.95	1.82	1.37	1.37	94	168	99.4	99.7
	2300		16.50	15.90			1.37	1.45				
07/12/80	600	3532	17.10	15.20			1.26	1.36				
	1400		17.10	16.00			1.28	1.35				
	2000		17.30	16.60	1.94	1.86	1.24	1.26	76	140	99.3	99.8
07/13/80	500	3556	16.40	16.30			1.29	1.44				
	1300		16.60	14.60			1.34	1.52				
	2000		16.20	15.50	1.89	1.85	1.43	1.43	91	140	99.9	99.9
	3000		18.10	15.40			1.47	1.45				
07/14/80	700	3565	15.00	15.50			1.26	1.51				
07/15/80	1200	3578	15.90	16.30	1.37	1.43	1.41	1.18	102	187	97.8	99.7
	1900		15.90	14.80	1.36	1.70	1.47	1.46	73	126	98.6	99.4
			15.30	15.80			1.47	1.75				

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS (%)		FILTER YIELD (A) (lb/hr/ft ²)		FILTER YIELD (B) (lb/hr/ft ²)		FeCl ₃ CONDITIONING (lb/ton sludge)		SOLIDS RECOVERY (%)	
		TF	BF	TF	BF	TF	BF	TF	BF	J1	TF	BF	TF
07/16/80	400	3602	4063	17.40	13.40	1.26	1.51	1.64	1.26	78	133	157	98.5
	900			14.40	14.40			1.64	1.59				99.4
07/17/80	1700	3626	4087	14.60	15.30			1.69	1.49				
	500			14.90	16.60	1.48	1.44	1.68	1.39	79	118	153	98.9
	1300			14.40	16.00			1.56	1.48				99.6
07/18/80	2000			14.50	15.90			1.67	1.49				
	700	3650	4111	15.20	15.50	1.53	1.51	1.67	1.67	62	120	144	99.0
	1530			12.90	14.00			1.70	1.63				99.6
07/19/80	2200			13.50	14.50			1.62	1.61				
	200	3674	4135	14.10	14.50	1.43	1.20	1.45	1.49	104	157	200	98.2
	1500			11.00	14.10			1.57	1.61				99.6
07/22/80	2300			16.20	14.30			1.27	1.68				
	1500	3720	4144	17.50	15.20	1.39	1.65	1.54	1.51	77	126	114	99.1
	1900			17.20	15.80			1.52	1.60				99.7
07/23/80	2300			17.40	16.30			1.40	1.56				
	400	3744	4168	17.20	17.00	1.34	1.82	1.45	1.56	69	106	108	98.7
	1300			16.60	15.00			1.53	1.58				99.7
07/24/80	1900			17.10	16.30			1.56	1.68				
	300	3763	4192	17.10	16.55	1.39	1.85	1.56	1.63	89	142	143	98.7
	1100			13.99	17.97			1.66	1.59				99.7
07/25/80	1800			16.63	16.58			1.69	1.67				
	500	3783	4216	17.90	17.10	1.24	1.56	1.52	1.63	85	146	140	97.9
	1400			16.50	17.80			1.35	1.85				99.3
07/26/80	2100			15.50	17.80			1.82	1.56				
	600	3798	4240	17.10	23.90	1.38	1.26	1.78	2.13	76	141	114	98.0
	1130			15.90	16.60			1.63	1.61				99.4
07/27/80	2200			18.20	15.80			1.58	1.65				
	700	3822	4264	17.20	16.30	1.41	1.79	1.66	1.73	62	111	115	98.2
	1400			17.00	11.40			1.71	1.21				99.4
07/28/80	2200			17.80	16.60			1.65	1.85				
	400	3855	4312	17.30	19.30	1.37	1.58	1.72	2.00	73	116	125	98.5
	900			15.30	15.20			1.65	1.66				99.7
07/29/80	2200			16.70	15.60			1.54	1.84				
	300	3855	4312	16.70	16.00	1.62	1.69	1.56	1.92	71	129	145	98.3
	815			16.90	15.80			1.69	1.98				99.7
07/30/80	1800			16.20	17.10			2.03	2.23				
	100	3861	4322	16.70	15.40			1.82	2.14	69	169	161	97.8
08/01/80	1300	3872	4346	16.30	16.50	1.28	1.58	1.31	1.51	75	149	161	97.7
	1900			16.40	16.50	1.43	1.58	1.40	1.45				99.4
08/02/80	600	3896	4370	15.60	19.20	1.40	1.57	1.29	1.50	74	149	153	99.0
	1400			16.70	16.40			1.51	1.36				99.5
08/03/80	2100			11.00	17.70			1.00	1.32				
	200	3920	4394	14.90	16.80	1.46	1.46	1.62	1.50	70	127	145	99.0
	1000			15.50	17.20			1.29	1.30				99.7
08/04/80	1700			16.60	16.80			1.64	1.33				
	0	3941	4418	16.80	17.20	1.28	1.44	1.50	1.43	72	147	136	98.9
	800			17.40	15.80			1.29	1.40				99.5
08/05/80	1600			14.80	15.50			1.41	1.43				
	1400	3954	4442	17.90	15.80	1.40	1.41	1.58	1.58	69	146	141	99.1
	2100			18.20	16.00			1.60	1.60				99.7
08/06/80	500	3978	4451	17.70	16.90	1.32	1.30	1.81	1.65	91	144	152	98.7
08/07/80	100	3997	4470	18.30	14.60	1.44	1.26	1.77	1.24	83	144	172	98.1
	500			14.40	16.90			1.74	1.36				99.6
	1500			15.40	14.70			1.76	1.67				

(continued)

TABLE E (continued).

DATE	TIME OF SAMPLE	ELAPSED TIME OF FILTER OPERATION		FILTER CAKE SOLIDS (% Solids)		FILTER YIELD (A) (lb/hr/ft ²)		FILTER YIELD (B) (lb/hr/ft ²)		FeCl ₃ CONDITIONING (lb/ton sludge)		SOLIDS RECOVERY (%)	
		TF	BF	TF	BF	TF	BF	TF	BF	J1	TF	TF	BF
	1630			16.40	15.24			1.78	1.46				

APPENDIX F

FEED SLUDGE FLOW RECORD

Table F lists the hours of filter operation, cumulative hours of operation, ferric chloride dose (mg/l), ferric chloride dose (lb/ton dry solids), and gallons sludge processed for the top feed vacuum filter and bottom feed vacuum filter. Also included are the ferric chloride dose (mg/l), ferric chloride dose (lb/ton dry solids) and gallons sludge processed for the Jones Island Filter House.

TABLE F. FEED SLUDGE DATA FOR THE TOP FEED FILTER, BOTTOM FEED FILTER AND JONES ISLAND FILTER HOUSE
FOR THE PERIOD FROM 6/26/79 TO 8/7/80.

FOR THE PERIOD FROM 6/26/79 TO 8/7/80.													
DATE	FEED SLUDGE FLOW RECORD				FeCl3 DOSE				FeCl3 lb/ton		SLUDGE PROCESSED		REMARKS
	HOURS OF FILTER OPERATION		ELAPSED TIME OF FILTER OPERATION		mg/l		d.s.		gallons				
	TF	BF	TF	BF	JF	BF	JF	BF	JF	BF			
06/26/79	24.0	24.0	24	24	-	-	-	-	-	-	-	-	-
06/27/79	24.0	24.0	48	48	-	-	-	-	-	-	-	-	-
06/28/79	24.0	24.0	48	48	-	-	-	-	-	-	-	-	-
06/29/79	24.0	24.0	72	72	-	-	-	-	-	-	-	-	-
06/30/79	24.0	21.0	96	93	-	-	-	-	-	-	-	-	-
07/01/79	24.0	24.0	120	117	-	-	-	-	-	-	-	-	-
07/02/79	8.0	24.0	144	141	945	945	945	141	141	141	141	2,710	-
07/03/79	8.0	24.0	152	165	947	947	947	145	145	145	145	2,660	-
07/04/79	24.0	19.0	184	184	609	609	609	86	86	86	86	3,020	-
07/05/79	24.0	-	208	184	981	981	981	130	130	130	130	2,480	-
07/12/79	2.0	24.0	210	208	1091	1091	1091	145	145	145	145	2,300	-
07/13/79	12.0	24.0	222	232	1184	1184	1184	162	162	162	162	2,620	-
07/14/79	10.0	12.0	232	244	963	963	963	136	136	136	136	2,690	-
07/15/79	24.0	24.0	256	268	1024	1024	1024	144	144	144	144	2,480	-
07/16/79	21.0	21.0	277	289	915	915	915	137	137	137	137	2,790	-
07/18/79	24.0	12.0	322	305	938	938	938	146	146	146	146	2,760	-
07/19/79	15.0	14.0	337	319	1173	1173	1173	148	148	148	148	2,520	-
07/20/79	9.0	9.0	346	328	1119	1119	1119	172	172	172	172	2,590	-
07/22/79	-	16.0	346	350	1099	1099	1099	160	160	160	160	2,430	-
07/23/79	-	24.0	346	374	1292	1292	1292	179	179	179	179	2,430	-
07/24/79	-	24.0	346	398	1242	1242	1242	154	154	154	154	2,500	-
07/25/79	2.0	-	348	398	1366	1366	1366	145	145	145	145	2,200	-
07/26/79	4.0	9.0	352	407	1158	1158	1158	132	132	132	132	2,530	-
07/27/79	14.0	24.0	366	431	1446	1446	1446	152	152	152	152	2,180	-
07/29/79	24.0	4.0	390	459	1620	1620	1620	179	179	179	179	2,150	-
07/30/79	10.0	20.0	400	479	1542	1542	1542	173	173	173	173	2,220	-
07/31/79	24.0	24.0	424	503	1615	1615	1615	158	158	158	158	2,320	-
08/01/79	17.0	24.0	441	527	1669	1669	1669	166	166	166	166	2,180	-
08/02/79	24.0	24.0	465	551	1531	1531	1531	153	153	153	153	2,290	-
08/03/79	5.0	18.0	470	569	1722	1722	1722	189	189	189	189	2,130	-
08/04/79	5.0	24.0	475	593	1460	1460	1460	155	155	155	155	2,270	-
08/05/79	11.0	24.0	486	617	1587	1587	1587	180	180	180	180	2,280	-
08/06/79	6.0	24.0	492	641	1521	1521	1521	181	181	181	181	2,470	-
08/07/79	24.0	24.0	516	665	1601	1601	1601	152	152	152	152	2,210	-
08/08/79	12.0	10.0	528	675	1626	1626	1626	157	157	157	157	2,210	-
08/09/79	24.0	24.0	552	699	1555	1555	1555	139	139	139	139	2,210	-
08/10/79	16.0	24.0	568	723	1730	1730	1730	179	179	179	179	2,220	-
08/11/79	24.0	24.0	592	747	1564	1564	1564	153	153	153	153	2,340	-
08/12/79	24.0	24.0	616	771	1653	1653	1653	153	153	153	153	2,300	-
08/13/79	24.0	24.0	636	791	1603	1603	1603	145	145	145	145	2,420	-
08/14/79	24.0	24.0	660	815	1744	1744	1744	158	158	158	158	2,160	-
08/15/79	24.0	24.0	684	839	1479	1479	1479	129	129	129	129	2,200	-
08/16/79	24.0	24.0	708	863	1355	1355	1355	134	134	134	134	2,140	-
08/17/79	18.0	18.0	726	881	1212	1212	1212	130	130	130	130	2,280	-
08/18/79	24.0	24.0	750	905	1228	1228	1228	140	140	140	140	2,400	-
08/19/79	24.0	24.0	774	929	1143	1143	1143	141	141	141	141	2,670	-
08/20/79	24.0	24.0	794	953	1186	1186	1186	150	150	150	150	2,650	-
08/21/79	12.0	12.0	806	965	1103	1103	1103	122	122	122	122	2,430	-
08/22/79	24.0	24.0	830	989	1308	1308	1308	144	144	144	144	2,150	-
					1299	1299	1299	135	135	135	135	2,360	-
												120,480	116,950

(continued)

TABLE F (continued).

DATE	HOURS OF FILTER OPERATION		ELAPSED TIME OF FILTER OPERATION		FeCl ₃ DOSE		FeCl ₃ lb/ton		SLUDGE PROCESSED		REMARKS
	TF	BF	TF	BF	JI	TF	JI	TF	JI	TF	
08/23/79	24.0	24.0	854	1013	1336	1336	136	136	136	136	BF
08/24/79	24.0	24.0	878	1037	1357	1357	136	136	136	136	BF
08/25/79	20.0	18.0	898	1055	1411	1411	141	141	141	141	BF
08/26/79	24.0	24.0	922	1079	1337	1337	132	132	132	132	BF
08/27/79	4.0	21.0	926	1100	1485	1485	147	147	147	147	BF
09/01/79	14.0	24.0	940	1139	1682	1682	174	174	174	174	BF
09/02/79	24.0	24.0	964	1163	1935	1935	204	204	204	204	BF
09/03/79	24.0	24.0	988	1187	1977	1977	198	198	198	198	BF
09/04/79	-	24.0	988	1211	1967	1967	194	194	194	194	BF
09/05/79	22.0	24.0	988	1230	2270	2270	199	199	199	199	BF
09/06/79	22.0	24.0	1010	1254	2176	2176	190	190	190	190	BF
09/07/79	17.0	24.0	1027	1278	2898	2898	251	251	251	251	BF
09/08/79	24.0	24.0	1051	1302	1732	1732	157	157	157	157	BF
09/09/79	24.0	24.0	1075	1321	1816	1816	173	173	173	173	BF
09/10/79	19.0	24.0	1094	1345	1811	1811	168	168	168	168	BF
09/11/79	19.0	24.0	1113	1369	1863	1863	177	177	177	177	BF
09/12/79	20.0	24.0	1133	1393	1757	1757	185	185	185	185	BF
09/13/79	20.0	24.0	1153	1417	1773	1773	195	195	195	195	BF
09/14/79	14.0	24.0	1167	1441	1821	1821	188	188	188	188	BF
09/15/79	24.0	24.0	1191	1465	2092	2092	209	209	209	209	BF
09/16/79	17.0	16.0	1208	1481	1888	1888	188	188	188	188	BF
09/17/79	24.0	24.0	1232	1502	2035	2035	191	191	191	191	BF
09/18/79	24.0	24.0	1256	1526	1783	1783	170	170	170	170	BF
09/19/79	24.0	24.0	1280	1550	1812	1812	171	171	171	171	BF
09/20/79	18.0	24.0	1298	1571	1824	1824	172	172	172	172	BF
09/21/79	24.0	24.0	1322	1595	2106	2106	206	206	206	206	BF
09/22/79	24.0	24.0	1346	1619	1974	1974	189	189	189	189	BF
09/23/79	24.0	24.0	1370	1643	2170	2170	198	198	198	198	BF
09/24/79	9.0	11.0	1379	1654	2227	2227	205	205	205	205	BF
02/18/80	-	9.0	1379	1653	564	564	84	84	84	84	BF
02/19/80	24.0	24.0	1403	1677	597	597	88	88	88	88	BF
02/20/80	24.0	24.0	1427	1701	562	562	80	80	80	80	BF
02/21/80	1.5	24.0	1429	1725	568	568	83	83	83	83	BF
02/22/80	24.0	17.0	1453	1742	488	488	73	73	73	73	BF
02/23/80	24.0	17.0	1453	1742	488	488	73	73	73	73	BF
02/24/80	24.0	24.0	1477	1766	539	539	76	76	76	76	BF
02/25/80	24.0	24.0	1501	1790	577	577	78	78	78	78	BF
02/26/80	6.5	6.5	1525	1814	526	526	74	74	74	74	BF
02/27/80	14.5	14.5	1532	1821	593	593	92	92	92	92	BF
02/28/80	16.0	24.0	1547	1836	585	585	86	86	86	86	BF
02/29/80	15.0	24.0	1563	1860	565	565	77	77	77	77	BF
03/01/80	20.0	24.0	1578	1884	585	585	83	83	83	83	BF
03/02/80	20.0	24.0	1598	1908	599	599	86	86	86	86	BF
03/03/80	24.0	19.0	1622	1927	558	558	79	79	79	79	BF
03/04/80	24.0	24.0	1641	1951	620	620	93	93	93	93	BF
03/05/80	24.0	24.0	1665	1975	609	609	85	85	85	85	BF
03/06/80	9.0	14.0	1689	1999	578	578	77	77	77	77	BF
03/07/80	6.5	24.0	1705	2039	567	567	79	79	79	79	BF
03/08/80	24.0	24.0	1729	2063	641	641	94	94	94	94	BF
03/09/80	24.0	24.0	1729	2063	641	641	94	94	94	94	BF

(continued)

TABLE F (continued).

DATE	FEED SLUDGE FLOW RECORD				ELAPSED TIME OF FILTER OPERATION				FeCl ₃ DOSE				FeCl ₃ lb/ton d.s.				SLUDGE PROCESSED				REMARKS
	HOURS OF FILTER OPERATION	BF	TF	BF	HOURS OF FILTER OPERATION	BF	TF	BF	JI	TF	BF	JI	JI	TF	BF	JI	JI	xe4	TF	BF	
03/10/80	24.0	24.0	1753	2087	24.0	24.0	1753	2087	626	626	626	93	93	93	93	93	93	3.960	176,930	171,510	
03/11/80	18.0	21.0	1771	2108	21.0	21.0	1771	2108	615	615	615	90	90	90	90	90	90	4.050	131,460	149,420	
03/12/80	21.0	23.0	1792	2131	23.0	23.0	1792	2131	628	628	628	92	92	92	92	92	92	4.000	128,250	136,910	
03/13/80	11.0	23.0	1803	2154	23.0	23.0	1803	2154	644	644	644	94	94	94	94	94	94	3.950	66,670	153,470	
03/14/80	15.0	24.0	1818	2178	24.0	24.0	1818	2178	638	638	638	82	82	82	82	82	82	3.870	96,110	151,740	
03/15/80	19.0	24.0	1837	2202	24.0	24.0	1837	2202	615	615	615	88	88	88	88	88	88	3.550	115,840	141,020	
03/16/80	22.0	24.0	1859	2226	24.0	24.0	1859	2226	665	665	665	88	88	88	88	88	88	3.540	137,390	143,080	
03/17/80	7.0	8.0	1866	2234	8.0	8.0	1866	2234	599	599	599	79	79	79	79	79	79	3.520	44,090	46,760	
03/18/80	20.0	23.0	1886	2257	23.0	23.0	1886	2257	734	734	734	87	87	87	87	87	87	3.690	110,870	125,150	
03/19/80	24.0	24.0	1910	2281	24.0	24.0	1910	2281	833	833	833	117	117	117	117	117	117	3.670	152,030	152,380	
03/20/80	24.0	24.0	1934	2305	24.0	24.0	1934	2305	767	767	767	139	139	139	139	139	139	3.670	168,800	170,800	
03/21/80	24.0	24.0	1958	2329	24.0	24.0	1958	2329	740	740	740	95	95	95	95	95	95	3.640	170,690	171,650	
03/22/80	24.0	24.0	1982	2353	24.0	24.0	1982	2353	729	729	729	93	93	93	93	93	93	3.410	171,800	174,130	
03/23/80	24.0	24.0	2006	2377	24.0	24.0	2006	2377	755	755	755	96	96	96	96	96	96	3.420	162,310	156,590	
03/24/80	24.0	24.0	2030	2401	24.0	24.0	2030	2401	785	785	785	101	101	101	101	101	101	3.500	157,600	163,170	
03/25/80	18.0	16.0	2048	2417	16.0	16.0	2048	2417	720	720	720	85	85	85	85	85	85	3.320	107,260	116,730	
03/26/80	24.0	24.0	2072	2441	24.0	24.0	2072	2441	797	797	797	103	103	103	103	103	103	3.410	155,540	160,710	
03/27/80	10.5	9.5	2083	2451	9.5	9.5	2083	2451	737	737	737	91	91	91	91	91	91	3.320	74,330	62,260	
03/28/80	-	19.0	2083	2470	19.0	19.0	2083	2470	1526	1526	1526	255	255	255	255	255	255	1.000	-	140,940	
03/29/80	-	24.0	2083	2494	24.0	24.0	2083	2494	1116	1116	1116	263	263	263	263	263	263	1.000	-	181,090	
03/30/80	-	24.0	2083	2518	24.0	24.0	2083	2518	1192	1192	1192	291	291	291	291	291	291	1.000	-	179,430	
03/31/80	-	24.0	2083	2542	24.0	24.0	2083	2542	1205	1205	1205	280	280	280	280	280	280	1.000	-	199,220	
04/01/80	-	19.0	2083	2561	19.0	19.0	2083	2561	1024	1024	1024	122	122	122	122	122	122	2.300	-	156,420	
04/02/80	3.0	16.0	2086	2577	16.0	16.0	2086	2577	797	797	797	84	84	84	84	84	84	2.390	22,730	120,290	
04/03/80	3.0	24.0	2089	2601	24.0	24.0	2089	2601	1078	1078	1078	90	90	90	90	90	90	2.800	25,770	187,360	
04/04/80	16.0	24.0	2105	2625	24.0	24.0	2105	2625	747	747	747	80	80	80	80	80	80	2.740	144,920	199,100	
04/05/80	-	24.0	2105	2649	24.0	24.0	2105	2649	742	742	742	85	85	85	85	85	85	2.140	-	204,290	
04/06/80	-	24.0	2105	2673	24.0	24.0	2105	2673	1105	1105	1105	92	92	92	92	92	92	2.130	-	190,170	
04/07/80	3.0	10.0	2108	2683	10.0	10.0	2108	2683	431	431	431	85	85	85	85	85	85	3.200	-	70,500	
04/08/80	24.0	-	2132	2683	-	-	2132	2683	906	906	906	90	90	90	90	90	90	3.210	174,790	-	
04/09/80	16.0	-	2148	2683	-	-	2148	2683	735	735	735	76	76	76	76	76	76	3.240	102,650	-	
04/10/80	24.0	-	2172	2683	-	-	2172	2683	783	783	783	93	93	93	93	93	93	3.210	157,030	-	
04/11/80	19.0	-	2191	2683	-	-	2191	2683	773	773	773	82	82	82	82	82	82	3.080	140,520	-	
04/12/80	20.0	-	2211	2683	-	-	2211	2683	942	942	942	82	82	82	82	82	82	2.940	162,490	-	
04/13/80	24.0	-	2235	2683	-	-	2235	2683	802	802	802	95	95	95	95	95	95	2.670	186,290	-	
04/14/80	24.0	-	2259	2683	-	-	2259	2683	933	933	933	90	90	90	90	90	90	2.670	185,980	-	
04/15/80	24.0	-	2283	2683	-	-	2283	2683	736	736	736	93	93	93	93	93	93	2.320	179,500	-	
04/16/80	24.0	-	2307	2683	-	-	2307	2683	950	950	950	107	107	107	107	107	107	2.760	187,940	-	
04/17/80	24.0	-	2331	2683	-	-	2331	2683	1069	1069	1069	93	93	93	93	93	93	2.820	196,300	-	
04/18/80	22.0	-	2353	2683	-	-	2353	2683	1058	1058	1058	120	120	120	120	120	120	2.310	173,710	-	
04/19/80	8.5	-	2362	2683	-	-	2362	2683	961	961	961	115	115	115	115	115	115	2.710	66,800	-	
04/20/80	10.0	23.0	2372	2706	23.0	23.0	2372	2706	1009	1009	1009	124	124	124	124	124	124	2.500	76,390	169,050	
04/21/80	9.0	10.0	2381	2716	10.0	10.0	2381	2716	877	877	877	125	125	125	125	125	125	2.500	76,390	169,050	
04/22/80	14.0	16.0	2395	2732	16.0	16.0	2395	2732	1038	1038	1038	130	130	130	130	130	130	2.280	75,610	96,020	
04/23/80	24.0	24.0	2419	2756	24.0	24.0	2419	2756	1005	1005	1005	132	132	132	132	132	132	2.710	111,170	132,440	
04/24/80	16.5	24.0	2436	2780	24.0	24.0	2436	2780	884	884	884	133	133	133	133	133	133	2.200	185,470	182,340	
04/25/80	9.0	24.0	2445	2804	24.0	24.0	2445	2804	924	924	924	119	119	119	119	119	119	3.150	123,960	186,410	
04/26/80	24.0	24.0	2469	2828	24.0	24.0	2469	2828	871	871	871	132	132	132	132	132	132	3.220	67,230	175,390	
04/27/80	23.0	23.0	2492	2851	23.0	23.0	2492	2851	1065	1065	1065	136	136	136	136	136	136	2.820	178,560	179,900	
04/28/80	24.0	20.0	2516	2871	20.0	20.0	2516	2871	1078	1078	1078	144	144	144	144	144	144	3.070	182,350	169,370	
04/29/80	8.0	-	2524	2871	-	-	2524	2871	1064	1064	1064	130	130	130	130	130	130	2.710	191,110	150,230	
04/30/80	-	3.3	2524	2874	-	-	2524	2874	1069	1069	1069	109	109	109	109	109	109	2.930	63,010	-	
									1034	1034	1034	105	105	105	105	105	105	3.310	-	24,910	

(continued)

TABLE F (continued).

FEED SLUDGE FLOW RECORD														
DATE	HOURS OF FILTER OPERATION		ELAPSED TIME OF FILTER OPERATION		FeCl3 DOSE		FeCl3 lb/ton			SLUDGE PROCESSED		REMARKS		
	BF	TF	BF	TF	mg/l	BF	TF	BF	TF	gallons				
05/01/80	8.5	20.0	2533	2894	1099	1240	1265	148	168	171	2.780	65,500	150,330	BF
05/02/80	24.0	24.0	2553	2918	921	1211	1401	110	145	167	3.260	182,540	108,150	
05/03/80	14.0	11.0	2567	2929	931	1171	1441	114	143	176	3.150	112,380	83,890	
05/04/80	-	-	2567	2929	922	-	1216	115	-	152	3.280	-	143,450	
05/05/80	12.0	16.0	2567	2959	753	-	1302	92	-	160	2.870	-	93,130	
05/06/80	20.5	24.0	2588	2975	1214	1214	1214	119	119	119	2.390	132,220	99,580	
05/10/80	13.5	24.0	2602	2999	1255	1255	1255	137	137	137	2.670	85,290	154,170	
05/11/80	9.0	6.0	2611	3005	1218	1218	1218	138	138	138	2.110	55,920	37,620	
05/12/80	11.0	6.5	2622	3012	1302	1302	1302	144	144	144	2.610	71,990	40,370	
05/13/80	12.0	24.0	2634	3036	1282	1282	1282	144	144	144	2.640	68,440	146,910	
05/14/80	22.0	24.0	2656	3060	1341	1341	1341	135	135	135	2.700	123,260	153,130	
05/15/80	8.0	24.0	2664	3084	1236	1236	1236	132	132	132	2.780	48,670	155,550	
05/16/80	24.0	10.0	2688	3094	1598	1598	1598	176	176	176	2.230	133,220	62,740	
05/17/80	24.0	24.0	2712	3118	1310	1310	1310	145	145	145	2.600	126,740	149,240	
05/18/80	24.0	24.0	2736	3142	1144	1144	1144	126	126	126	2.650	126,590	150,290	
05/19/80	16.0	21.0	2752	3163	1221	-	-	133	-	-	2.620	79,850	123,290	
05/20/80	18.0	20.0	2770	3183	1197	286	288	128	30	31	2.740	104,070	123,910	
05/21/80	18.0	24.0	2788	3207	1293	399	405	136	42	42	2.750	99,310	161,400	
05/22/80	24.0	24.0	2812	3231	1416	295	490	149	31	51	2.690	141,223	153,570	
05/23/80	24.0	15.0	2836	3246	1682	390	540	162	38	52	1.950	142,180	84,350	
05/24/80	23.0	20.0	2859	3266	1125	1752	1764	119	185	186	2.770	144,780	138,190	
05/25/80	6.0	2.0	2865	3266	1168	1773	2669	99	151	227	2.540	33,530	11,880	
05/26/80	2.5	11.0	2868	3279	1060	1759	2026	109	179	209	2.620	16,640	67,480	
05/27/80	21.0	21.0	2889	3307	1272	1632	1956	131	168	202	2.360	125,086	104,320	
05/28/80	-	6.5	2889	3307	-	2671	2671	-	-	239	2.630	-	32,790	
05/29/80	8.0	2.5	2897	3310	1715	2758	3155	124	199	228	2.400	70,420	14,070	
05/30/80	24.0	19.5	2921	3330	1440	2354	2778	120	196	232	2.420	154,280	83,510	
05/31/80	21.5	-	2943	3330	1693	2570	-	129	196	-	2.110	116,550	-	
06/01/80	14.0	2.0	2957	3332	1459	2324	-	131	208	-	2.400	73,320	2,700	
06/02/80	4.3	-	2961	3332	1524	2436	-	128	204	-	2.630	24,380	-	
06/03/80	11.3	1.5	2973	3334	1537	2333	1366	113	171	100	2.320	61,980	5,670	
06/04/80	14.0	4.3	2987	3348	1579	2581	3055	122	200	237	2.160	61,630	51,730	
06/05/80	10.5	9.5	2998	3358	1590	2426	-	119	182	294	2.100	51,980	36,660	
06/06/80	9.0	8.0	3007	3366	1830	-	1886	128	261	132	1.950	29,480	25,670	
06/07/80	3.0	3.0	3010	3405	2010	-	2010	135	-	132	1.880	12,480	12,480	
06/08/80	8.7	24.0	3019	3405	1947	1947	1947	123	123	123	1.800	27,310	72,670	
06/09/80	7.0	24.0	3026	3429	1718	1718	1718	103	103	103	1.990	25,400	76,690	
06/10/80	12.2	16.0	3026	3445	1206	1206	1206	128	128	128	2.430	1,060	58,720	
06/11/80	-	8.0	3026	3453	896	896	896	116	116	116	2.970	-	49,930	
06/12/80	10.5	24.0	3037	3477	705	705	705	87	87	87	4.270	58,450	134,750	
06/13/80	24.0	24.0	3061	3501	645	645	645	94	94	94	4.260	122,740	123,700	
06/14/80	24.0	8.0	3085	3509	858	858	858	93	93	93	3.810	123,800	37,723	
06/15/80	9.0	4.0	3094	3513	938	938	938	136	136	136	3.330	49,940	24,090	
06/16/80	24.0	24.0	3118	3537	1073	1073	1073	141	141	141	2.990	123,980	138,300	
06/17/80	11.0	4.0	3129	3541	1171	1488	2345	132	168	265	2.490	72,890	17,210	
06/18/80	24.0	24.0	3153	3565	1134	1457	1577	130	168	181	2.220	162,660	153,510	
06/19/80	24.0	24.0	3177	3589	915	1468	1594	104	167	181	3.140	156,030	142,400	
06/20/80	24.0	15.0	3201	3604	957	1380	1409	113	162	166	3.240	159,880	88,400	
06/21/80	24.0	24.0	3225	3628	875	1393	1321	103	164	156	3.690	156,710	133,280	
06/22/80	18.0	24.0	3243	3652	919	1251	1398	104	142	158	3.540	110,200	119,720	
06/23/80	21.0	21.0	3264	3673	1140	1613	2386	131	185	274	2.640	114,140	90,900	
06/24/80	-	-	3264	3673	209	-	-	-	-	-	2.170	-	-	

TABLE F (continued).

DATE	FEED SLUDGE FLOW RECORD			FeCl ₃ DOSE			FeCl ₃ lb/ton			SLUDGE PROCESSED			REMARKS
	HOURS OF FILTER OPERATION	ELAPSED TIME OF FILTER	BF	JI	TF	BF	JI	TF	BF	JI x66	TF	BF	
06/25/80	23.0	3287	3697	1019	1975	2061	93	180	188	1.740	142,360	157,570	
06/26/80	24.0	3311	3721	1065	1734	1685	101	165	161	2.090	171,820	167,400	
06/27/80	24.0	3325	3745	855	1521	1357	89	159	142	2.110	170,120	171,260	
06/28/80	24.0	3359	3769	799	1380	1247	91	158	143	1.920	181,890	182,490	
06/29/80	24.0	3383	3793	729	1200	1106	76	125	115	2.090	185,790	186,630	
06/30/80	24.0	3407	3819	632	1193	1144	72	136	130	2.490	181,690	195,820	
07/01/80	24.0	3331	3841	737	1293	1176	82	144	131	2.130	175,720	189,140	
07/02/80	16.0	3347	3857	737	1401	1531	81	153	167	2.440	110,730	123,830	
07/03/80	24.0	3371	3881	735	1249	1355	81	138	150	2.310	157,510	154,870	
07/04/80	24.0	3395	3889	1090	1462	1831	127	170	213	1.680	157,960	48,200	
07/05/80	24.0	3419	3889	788	1593	-	87	177	-	2.430	152,390	-	
07/06/80	24.0	3443	3889	956	1748	-	106	194	-	1.930	137,640	-	
07/07/80	4.0	3447	3889	835	1584	-	101	192	-	2.440	24,860	-	
07/08/80	5.0	3452	3900	839	1502	1760	95	171	200	2.310	31,180	81,150	
07/09/80	19.0	3471	3924	892	1306	1454	103	150	167	1.950	147,050	164,200	
07/10/80	24.0	3484	3934	657	1390	1444	80	169	175	2.360	187,300	36,650	
07/11/80	24.0	3508	3958	810	1447	1420	94	168	165	1.920	195,310	182,280	
07/12/80	24.0	3532	3982	677	1242	1354	76	140	130	1.990	188,610	180,630	
07/13/80	24.0	3556	4006	822	1273	1315	91	140	145	1.930	179,840	175,950	
07/14/80	8.5	3565	4021	728	1332	1241	102	187	174	2.670	59,140	105,170	
07/15/80	13.0	3578	4039	642	1108	1329	73	126	151	2.630	72,080	124,890	
07/16/80	24.0	3602	4063	678	1167	1374	78	133	157	2.360	124,210	148,610	
07/17/80	24.0	3626	4087	738	1114	1440	79	118	153	2.660	135,660	131,870	
07/18/80	24.0	3650	4111	585	1142	1372	62	120	144	3.180	139,430	136,880	
07/19/80	24.0	3674	4135	958	1454	1847	104	157	200	3.120	133,220	112,420	
07/20/80	23.0	3697	4135	193	358	-	21	39	-	3.370	107,270	-	
07/21/80	-	3697	4135	204	-	-	-	-	-	3.290	-	-	
07/22/80	23.0	3720	4144	726	1182	1069	77	126	114	2.790	122,710	56,890	
07/23/80	24.0	3744	4168	683	1056	1072	69	106	108	2.590	116,400	157,760	
07/24/80	19.0	3763	4192	878	1410	1418	89	142	143	2.740	96,000	161,470	
07/25/80	20.0	3783	4216	808	1396	1341	85	146	140	2.820	93,340	141,080	
07/26/80	15.0	3798	4240	763	1410	1141	76	141	114	3.170	74,550	108,660	
07/27/80	24.0	3822	4264	615	1106	1153	62	111	115	2.920	121,580	154,940	
07/28/80	9.0	3855	4312	690	1088	1174	73	116	125	1.880	47,340	145,620	
07/29/80	24.0	3855	4312	736	1336	1498	71	129	145	1.730	134,930	140,710	
07/30/80	6.0	3861	4322	666	1632	1555	69	169	161	2.480	28,700	58,740	
07/31/80	-	3861	4322	686	-	-	121	-	-	3.730	-	-	
08/01/80	11.0	3872	4346	558	1102	1196	75	149	161	3.800	76,490	184,080	
08/02/80	24.0	3896	4370	546	1093	1124	74	149	153	3.640	164,970	184,760	
08/03/80	24.0	3920	4394	498	906	1038	70	127	145	2.900	176,380	175,940	
08/04/80	21.0	3941	4418	534	1088	1005	72	147	136	2.480	130,710	167,930	
08/05/80	13.0	3954	4442	542	1143	1195	69	146	141	2.400	83,560	154,830	
08/06/80	24.0	3978	4451	681	1076	1133	91	144	152	2.410	152,630	56,580	
08/07/80	19.0	3997	4470	628	1091	1299	83	144	172	2.600	129,700	114,200	

SECTION 11

GLOSSARY

Acid House - The building in which ferric chloride conditioning of activated sludge takes place at the Milwaukee Jones Island Wastewater Treatment Plant.

Blinding - See filter blinding.

Blowoff - That portion of the vacuum filtration cycle immediately prior to cake discharge in which an air blow from the inside of the filter cloth (side against the drum) is applied to the cake to aid in separation of the filter cake and filter cloth.

Bottom Feed Vacuum Filtration - A conventional technique of dewatering sludges which a horizontal cylinder rotates in a vat located below the cylinder where a vacuum is applied to the cylinder to draw water through a filtration medium wrapped around the cylinder. Sludge solids are retained on the medium and water drawn from the solids as the drum rotates. The solids are then discharged.

Cake Discharge - The manner in which the vacuum filter cake separates from the filter cloth. It is described in a manner identifying its case of separation, e.g. excellent, good or poor.

Cake Solids - The percentage dry sludge solids in the vacuum filter cake. It is calculated from the formula:

$$[(\text{dry cake weight in grams-tare})/(\text{wet cake weight-tare})] \times 100$$

Cake Thickness - The actual thickness of the vacuum filter cake. It is related to solids loading.

Cloth Age - The length of time a particular filter cloth has been in service actually filtering sludge. This time does not include cloth wash time.

Cloth Life - The effective length of time a filter cloth lasts in actual sludge filtration before it must be replaced by a new cloth.

Cloth Washing Characteristics - All those parameters describing how a cloth is washed - the length of cloth wash, the frequency of cloth washes, the type of wash (water, steam or acid), and the manner in which the cloth is washed.

Cycle Time - The time required for a vacuum filter to make one complete drum revolution.

Dead Time - That portion of the vacuum filter cycle that is unproductive for sludge pickup or dewatering. This portion of the cycle accommodates cake discharge and that portion of the drum that is between the scraper and sludge level in the filter vat.

Dry Time - That portion of the vacuum filtration cycle occurring between the point of drum rotation out of the sludge to the point of vacuum release.

Filter Blinding - The deposition of solids within the weave of a filter cloth such that the cloth cannot pick up any new solids, as it cannot discharge the solids within the weave. No sludge dewatering occurs in those areas exhibiting gross blinding.

Filter Panel - A section into which a vacuum filter is discretely divided such that each panel performs the vacuum filtration process separate from all other panels. Separate drain lines are provided for each panel, and each panel is sealed from all other ones to prevent air leakage into the various filter areas, notably the discharge and blowoff cycles. There are 24 panels around the circumference of the vacuum filter.

Filter Yield - The mass of dry sludge solids picked up per unit area of vacuum filter in a unit of time, normally measured as lb/sq ft/hr. Yield is calculated from these formulas:

$$\text{Yield based on sludge flow} = \frac{(\text{gallon sludge})(\text{mg solids})(3,785 \text{ liters})}{(24 \text{ hours}) \quad (\text{liter}) \quad (\text{gallon})}$$

$$\times \frac{1}{(\text{filter area, ft}^2)}$$

$$\text{Yield based on cake solids} = \frac{(\text{mass filter cake, gms})(1 \text{ lb})(\text{filter area, ft}^2)}{(\text{sample area, ft}^2) \quad (454 \text{ gm}) \quad (\text{cycle time, min})}$$

$$\times \frac{(60 \text{ min})}{(\text{hour})} \quad \frac{1}{(\text{filter area, ft}^2)}$$

Filtrate Blowback - The discharge of vacuum filtrate during cake discharge and blowoff, thus rewetting the dewatered filter cake to some degree.

Filtrate Suspended Solids - The suspended material concentration in the water passing through the vacuum filter cloth.

Gravity Drain Time - That portion of a top feed vacuum filtration cycle equal to the length of time it takes the panel to rotate into the sludge hopper during the pickup cycle. No vacuum is applied to this panel until it is completely submerged in sludge.

Nap - A fuzzy surface of a filter cloth raised by a fine steel comb to increase particle retention.

Pickup Time - That portion of the vacuum filtration cycle occurring during the time the drum is submerged in the sludge; synonymous with form time.

Pilot Filter - The filter used in a previous study to investigate both bottom and top feed filtration being, 4 ft dia. by 6 ft long.

Production Filter - The large filters at the Milwaukee Jones Island plant that normally dewater all their waste activated sludge, the majority being 14 ft dia. by 16 ft long.

Sludge Conditioning - The act of making sludge more amenable to dewatering by various techniques.

Sludge Conditioning Chemicals - Those chemicals employed to make a sludge more amenable to dewatering.

Solids Loading - The mass of dry sludge solids picked up per unit area of filter; a measure of cake thickness. It is calculated by the formula:

$$\text{Solids loading} \quad \text{lb/sq ft} = \frac{(\text{mass filter cake, grams})}{(453.6)} \div (\text{sample area, ft}^2)$$

Solids Recovery - The amount of solids picked up in the filter cake expressed as a percentage of the total solids concentration in the feed sludge.

Specific Resistance - A measure of the ability of a vacuum filter sludge cake to impede the flow of water through its pore structure; utilized to measure the effect of sludge conditioning chemicals on filtration.

Submergence - A measure of sludge depth in the vacuum filter; usually expressed as the percentage of the drum diameter beneath the sludge in the filter vat.

Top Feed Vacuum Filtration - A technique for sludge dewatering similar to bottom feed vacuum filtration except that the filter drum rotates through a sludge hopper positioned on top of the cylinder. The rest of the filter cycle and ancillary equipment is the same as for bottom feed filtration.

T-test - (Paired Comparison Test) - A statistical procedure that determines if the mean of the two sets of paired independent observations are equivalent.

Vacuum Level - The average vacuum utilized to operate the vacuum filter during any one test.

Wear Sheet - A sheet of polyolefin material six inches wide that is used to form a seal along the horizontal edge of the top feed filter sludge hopper. The material also serves to reduce wear on the filter cloth and the horizontal extruded seal.